Azadi Ka Amrit Mahotsav

सत्यमेव जयते
Ministry of Housing and Urban Affairs
Government of India

Smart City
MISSION TRANSFORM-NATION

National Institute of Urban Affairs

SAAR
Smart cities and Academia towards Action and Research

75+ Case Studies of Innovative Projects of Smart Cities Mission

Part B

Climate Change and Resilient Cities

SPA
Vijayawada

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Shibpur

CEPT University
Ahmedabad

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Ministry of Housing and Urban Affairs
Government of India

Smart cities and Academia towards Action and Research

Part A: **Urban Management**

Part B

Climate Change and Resilient Cities

Part C: **Urban Infrastructure**

Institutes:

NATIONAL INSTITUTE OF URBAN AFFAIRS
Smart cities and Academia towards Action and Research: SAAR
Part B: Climate Change and Resilient Cities
October, 2022

National Institute of Urban Affairs

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STAY CONNECTED

Message from the Minister

Hardeep S Puri
Minister,
Ministry of Housing & Urban Affairs

The basic objective of various National missions of GOI is to accelerate economic growth and to improve ease of living for all. Good planning and fit-to-context development strategies have been key factors in achieving the above-mentioned objectives.

In order to critically analyze planning trends and development processes, it is necessary to deepen the linkages between the world of practice, i.e., urban governments, and the world of knowledge, i.e., academia.

As part of the Azadi Ka Amrut Mahotsav (AKAM) celebrations across the country, we launched the Smart Cities and Academia Towards Action & Research (SAAR) program, a joint initiative of MoHUA, NIUA and leading Indian academic institutions of the country. Under the program, 15 premier architecture & planning institutes in the country have documented case studies based on 75 projects undertaken by Smart Cities Mission. I am glad that SAAR: A compendium of 75 Smart Cities Projects is being released today. to showcase best practices across India. I am pleased that Smart Cities Mission, MoHUA, NIUA, and Premier Institutes of the nation, have jointly supported the production of this compendium. I am confident that this compendium will help young students and future practitioners to deepen their knowledge in the urban domain.

Message from the Secretary

Manoj Joshi
Secretary,
Ministry of Housing & Urban Affairs

The Smart Cities Mission's urban projects are lighthouse projects for other aspiring cities. As more and more urban infrastructure projects get completed under the Smart Cities Mission, it is important that we learn from them. Thus, documenting the impact of these urban projects is necessary. For this purpose, the Ministry of Housing and Urban Affairs (MoHUA) and the National Institute of Urban Affairs (NIUA) have jointly engaged with the premier academic institute of the country, to launch Smart cities and Academia Towards Action & Research (SAAR)'.

SAAR is a unique program that aims to provide a platform for the students to engage in the 'here and now of the urban domain. This program will facilitate greater engagement between academic institutes and urban flagship missions to maximize learning for students, institutes, and cities. As a first step, this program provides the opportunity for students to contribute to the creation of a compendium of 75 urban infrastructure projects in India under the Smart Cities Mission.

I am delighted to see the commendable efforts by the team of Smart Cities Mission, Ministry of Housing and Urban Affairs, NIUA, and the 15 Premier Institutes in developing this compendium. I believe this compendium will help us to know about the on-ground achievements of Smart Cities Mission and its significant social and economic benefits.

Message from the Joint Secretary

Kunal Kumar
Joint Secretary, Ministry of Housing and Urban Affairs
Mission Director, Smart Cities Mission
Vice President, National Institute of Urban Affairs

Perspectives, skills, and energy of the youth are essential ingredients for a prosperous city. The idea of a smart city has emerged at the confluence of increasing urbanization and the emergence of new technologies to address its consequences. Over 8000+ Smart City projects are either being developed or have got completed in the 100 Smart Cities.

In this background, we launched the Smart Cities and Academia Towards Action & Research (SAAR) program. It is a joint initiative of MoHUA, NIUA, and leading Indian academic institutions of the country, I am delighted to see the fruits of our combined labor. The hard work put in by partner institutions along with NIUA and the SCM team in MoHUA has been exemplary. Professors and students who documented the case studies on the ground, the cities which supported them need to be commended for forging such an enriching partnership and creating new pathways for holistic learning. The 75 case studies from 47 smart cities covered in the compendium will contribute to the discourse on urban development amongst all relevant stakeholders. My congratulations to the team and appeal to everyone in the urban sector to grab a copy as soon as possible!

Foreword by the Director - NIUA

Hitesh Vaidya
Director,
National Institute of Urban Affairs

Nearly four billion of the world's population under the age of 30 lives in urban areas. In less than a decade from today, 60% of the world's urban residents will be less than 18 years old. In India also, more than 50% of population is below 30 years. These numbers point to the fact that even though our cities are growing, they are also getting younger. Keeping this in consideration youth impact is a key factor in the discourse of our transforming agenda.
NIUA is dedicated to bridging the gap between policy and practice by creating and disseminating knowledge, building the long-term capacities of practitioners, and supporting ground-level work that contributes to national and global commitments. This compendium, created as part of the Smart Cities and Academia Towards Action & Research (SAAR) program, was an opportunity for us to engage young minds in this endeavour. The 75 case studies in this volume reflect the research and analytical skills of scholars from 15 academic institutions in India.
However, while I believe that the youth needs to be proactive and explore new solutions to the problems of a rapidly urbanising world, it is also our responsibility to nurture their ideas and guide them in making meaningful contributions to the urban discourse.

These case studies draw valuable lessons from projects under the Government of India's Smart Cities Mission. From the vertical gardens in Jammu to smart streetlights in Nashik, and from the use of bio-CNG to fuel Indore to improving pedestrian paths in Gangtok, these projects provide rich insights into how urban infrastructure and management can be innovative, effective and sustainable. I hope the learnings from these cases transcend the pages of this book and become a part of the curriculum in colleges and institutes across the country, inspiring the next generation of urban planners.

I am delighted that NIUA had the chance to not only evaluate and encourage their work, but also provide them with a platform to present it. I convey my thanks to the team from Ministry of Housing & Urban Affairs and my team Arvind Varshney, Purva Sharma, Himani Verma, Deep Pahwa, Bhavnesh Bhanot, Devender Rawat, Ambika Malhotra and Kapil Kumar– for putting together this compendium and supporting this effort.

Message from HOD

We are very delighted to be the part of such thoughtful project of NIUA and congratulates the whole team including all institutes in making it a great success. The reviews of the studies are very insightful, and it has further given great scope of innovation in the current projects. Hope to see further continuations in such initiatives with impactful collaboration.

Prof. Aarati Petkar
Coordinating Professor,
Department of Architecture College of Engineering, Pune

A pragmatic initiative by MoHUA and NIUA which facilitated students to do in-depth investigation of the projects done by Smart City Mission. The whole process was an eye opener for students as it involved stakeholder meetings and public interactions to understand ground reality on how such development programmes influence and inspire daily lives of citizens.

Dr. Bejene S Kothari
Professor and Head of the Department,
Department of Architecture College of Engineering Trivandrum

The compendium projecting uniqueness of these projects, highlighting observed and targeted physical and socio-economic impact along with recommendations based on global benchmarks, will be an extremely relevant reading material for future professionals and students.

Prof. (Dr.) Subrata Chattopadhyay
Coordinating Head from IIT Kharagpur

The initiative like SAAR should be more often taken by the ministry, a platform to learn, build connections, acquire skills and gain recognition while part of a national mission for academic institutions, students, scholars and researchers.

Dr. Nand Kumar
MNIT, Jaipur

It has been an honour to participate in a remarkable partnership initiative involving students, practitioners and policy-makers. A compendium of case studies will immensely help us all, especially students, to understand the experience of project implementation, actor practices and institutional perspectives in the working of Smart City Mission.

Dr. Nandineni Rama Devi
Director Professor, Manipal School of
Architecture and Planning, MAHE Manipal, Udupi, Karnataka.

Bhopal Students have been benefitted immensely from the site visits, consultations, and documentation. The initiative we feel has met its objective of making YOUNG URBANISTs learn, share and shape India's Urban Development Journey. Congratulations Team SAAR.

Prof. (Dr.) Jagdish Singh
HOD, MANIT, Bhopal

The assessment of the projects post implementation and completion was an important learning for the students. The critical thinking thus developed will bridge the gap between academia and urbanity to make cities resilient to address future challenges.

Prof. Ainsley Lewis
Dean, Kamla Raheja Vidynidhi
Institute of Architecture and Environmental Studies

Experience of working with smart city project immensely benefited the team of faculty and students

Dr. O P Bawane
Principal RV College of Architecture, Bangalore

“This project gave the students and faculty exhilarating learning experience on real world diversified projects of Smart city. We hope to continue our association with Ministry of Housing and Urban Affairs and National Institute of Urban Affairs in years to come.”

Dr. K. Pratheep Moses
Professor and Head, Department of Planning,
SAP Campus, Anna University, Chennai

“SAAR gave the golden opportunity to our young minds to experience the on-ground challenges, successes, and pitfalls from ideation to implementation, role of leadership, feedback from users and way forward.”

Prof. Hina Zia
Dean of Faculty of Architecture and Ekistics, Jamia Millia Islamia

“I am sure that the compendium will be instrumental in learning from the on-ground experience and will lead the way forward in the successful development of infrastructure as per the aspiration of citizens.”

Prof. Chandra Charu Tripathi
Director, School of Planning and Architecture, Bhopal

“In the SAAR Compendium which has diverse urban infrastructure projects across the geography, the planning students got involved to develop case studies under the guidance of the Professors, which is great opportunity to create robust interface between the Academia and Industry interaction to gain the urban vision on real world.”

Dr. Ramesh Srikonda
Director and Professor,
School of Planning and Architecture Vijayawada

“Exchanges with the stakeholders and beneficiaries at the grassroots level have elucidated momentous insights into the implementation of the flagship Smart City projects. This interface has immense potential for knowledge transfer to urban practitioners, planning professionals, and academia at large. We are delighted as our joint efforts come to fruition with this publication and look forward to more opportunities like this.”

Gaurav Raheja
Ph.D., DAAD Fellow Head, Department of Architecture & Planning Professor,
Department of Architecture & Planning Joint Faculty,
Department of Design, Indian Institute of Technology (IIT), Roorkee

“The SAAR compendium will have far reaching impact on the urban development sector in India and academia at large. CEPT University is happy to be a part of this initiative and we look forward to meaningful collaboration with MOHUA in near future.”

Tridip Suhrud
Professor and Provost, CEPT University

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This compendium would not have been possible without the shared effort, research and analysis by the students of planning. We thank all 15 institutions, their students and professors for contributing and cooperating in this project.

I would like to express my gratitude towards Shri Kunal Kumar, Joint Secretary, Ministry of Housing and Urban Affairs, for giving this opportunity to the young leaders of the country and for giving his guidance, constant supervision, and encouragement, which helped in completion of the project. I am also thankful to Mr. Vikas Chandra, programme team leader, management unit of SCM for all the kind support and conceptualizing the project. I would like to acknowledge and give my warmest thanks to Mr. Saswat Bandyopadhyay, Project Director, Centre of Urban Planning and Policy (CUPP), CEPT for ideating the project and to the whole working group for their continuous technical and coordination support.

Special thanks to Gargi Roy, Aman Singh Rajput, Saivarsha Akavarapu and Amit Kumar for their contribution and coordination with the universities for collating data for compiling this compendium.

I also want to express special gratitude to the team at NIUA for their complete support till the end, specifically Arvind Varshney and Purva Sharma, who helped take this project from conception to completion. I would also like to extend my gratitude to other institute members- Himani Verma, Ambika Malhotra, Anusha Sharma, Mehak Bakshi, Anirban Bera, Deep Pahwa, and the whole editorial and design team for lending their time and ideas. They helped by structuring the plan, developing the website and brochures supporting this voluminous compendium.

This handbook would not have been possible without the shared effort, research and analysis by the students of the 15 partner institutes documenting the projects-

1. Anna University
2. Center for Environment Planning and Technology, Ahmedabad
3. College of Engineering, Pune
4. College of Engineering, Trivandrum
5. Department of Architecture & Planning, Manipal University
6. Indian Institute of Science and Environment Technology, Shibpur
7. Indian Institute of Technology, Kharagpur
8. Indian Institute of Technology, Roorkee
9. Jamia Millia Islamia, Delhi
10. Kamla Raheja Vidyanidhi Institute for Architecture, Mumbai
11. Malaviya National Institute of Technology
12. Maulana Azad National Institute of Technology
13. R V College of Architecture, Bangalore
14. School of Planning and Architecture, Bhopal
15. School of Planning and Architecture, Vijayawada

In the month of January to February 2022; the team of students, and mentors from these premier institutions visited the above-mentioned 47 smart cities to conduct a field investigation. This was followed by a series of data analysis & documentation, a national research methodology workshop for the participating students, a peer review of the first draft, a final submission made by research students to their respective institutions, and then the institutes submitted the final draft of the research paper to NIUA. All these efforts culminated in to develop a compendium of 75 urban projects that are impacting the lives of urban citizens.

Throughout the process, the Smart Cities Mission, MoHUA, and NIUA acted as the linkage between the Institutions and the Smart Cities to facilitate the documentation of specific landmark projects under the Mission.

I hope this compendium will serve as a valuable “lessons learned” document for architecture/ planning students and universities and a springboard for practical future courses and disciplines across India.

Executive Summary

‘Smart cities and Academia Towards Action & Research (SAAR)’ program, is a joint initiative by MoHUA, the National Institute of Urban Affairs (NIUA), and leading Indian academic institutions of the country. Under the program, 15 premier architecture and planning institutes of the country worked with Smart Cities to document the landmark projects undertaken under the Smart Cities Mission. This document captures the learnings from best practices, provides opportunities for engagement on urban development projects to students, and enables real-time information flow between urban practitioners and academia.

The Smart Cities Mission’s urban projects are lighthouse projects for other aspiring cities. Since the start of the Mission in 2015, the 100 Smart Cities have been developing a total of 7,742 projects with an investment of Rs. 1,81,500 crore. Under the SAAR program, it is envisaged to prepare a compendium of 75 landmark urban projects of the Smart Cities Mission. These 75 urban projects are innovative, multi-sectoral, and have been implemented across different geographies across India.

This compendium will act as a first point of reference for future research in the field and will help to disseminate learnings from projects under the Mission, thus enhancing peer-to-peer learning.

The 75 urban projects covered in this SAAR compendium are distributed across 47 Smart Cities. The cities include: Agra, Ajmer, Chandigarh, Dehradun, Dharamshala, Faridabad, Jaipur, Jammu, Kanpur, Saharanpur, Shimla, Srinagar, Belgavi, Bengaluru, Chennai, Coimbatore, Erode, Kakinada, Kochi, Manguluru, Shivamogga, Thanjavur, Thiruchirapalli, Thiruvananthapuram, Tumakuru, Ahmedabad, Dahod, Nagpur, Nashik, Pune, Surat, Thane, Vadodara, Bhubaneswar, New Town Kolkata, Ranchi, Vishakhapatnam, Bhopal, Gwalior, Indore, Raipur, Sagar, Ujjain, Jabalpur, Agartala, Gangtok, and Namchi.

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Part B: Climate Change and Resilient Cities

B1

Canal Corridor-Linear Park Development

Surat's Canal Corridor wwark Development -Critical Review of Indian Smart City Project

Name of the project: *Canal Corridor with Linear Park.*
Location: *Surat, Gujarat.*
Year of project implementation: *2018 – 2020.*
Sector: *Mobility and NMT (Road Development Department)*
Project Cost: *Rs 54.41 crore.*
Linkages to SDGs:

- ***SDG 3:*** *Health and Well-Being – Sub-Goals - 3.4, 3.6 and 3.9*
- ***SDG 5:*** *Gender Equality – Sub-Goals - 5.2*
- ***SDG 8:*** *Decent Work for All – Sub-Goals - 8.8*
- ***SDG 11:*** *Sustainable Cities and Communities – Sub-Goals - 11.7*
- ***SDG 13:*** *Climate Change – Sub-Goals - 13.1 and 13.2*

Institute: *Center for Environment Planning and Technology (CEPT), Ahmedabad*
Advisors: *Dr. Saswat BandhopadhyayDr. Sejal Patel*
Students: *Yasin Kabadia*

Keywords: *Smart City Mission, Green Corridors, Canal Corridors, Public spaces, Mobility and SDGs.*

Abstract:

Linear parks with Green and Blue infrastructure not only improve people's living conditions, but also assist them in adapting to the negative effects of extreme climatic events. Green Corridors also aid in the reduction of carbon emissions and air pollution. Public spaces with such infrastructure, which are at the core of urban regions, are an essential component in creating cities that are inclusive, healthy, functional and productive. They can help the city achieve long-term sustainability by delivering environmental, social, economic and health advantages. Public open space has been recognised under the 11th SDG to assist and develop safe, inclusive, resilient and sustainable cities.

The Canal Corridor with Linear Park Development Project was taken up by Surat Municipal Corporation under the Surat Smart City Mission to improve the present unhealthy condition prevailing along the existing canal, to have maximum utilisation of the road width within the city and to build such an environment along the canal road which will not only improve the mobility on the corridor but will also create an environment-friendly atmosphere for smart citizens within the city. The project deals with the development of a 60-m wide and 3-km long canal corridor from Anuvratdwar Junction to Jamnaba Park in the South-West Zone of the city. A practical and analytical approach was taken into consideration for data collection through documentation and evaluation of the recently developed Canal Corridor project in Surat City. This project was studied in reference to the selected parameters adopted from PPS (Project for Public Spaces) which will investigate in detail the intangible and tangible indicators through qualitative and quantitative measures. First, the quantitative aspects through semi-structured interviews, FGD with the stakeholders like Smart City government officials, experts, city planners, environmental specialists, etc were considered. Secondly, ethnographic research methods were used to study qualitative aspects through observation and activity mapping and semi-structured interviews with local visitors, residents, shopkeepers etc.

Expected outcome from the project is a formal sport creation, preservation of natural environment and improved quality of life making the city and the citizens healthy, promoting social contacts, curtailing greenhouse emission, helping in fighting global warming and to create economic opportunity in the city.

Case Study: **B1**

1. Introduction

The Government of India announced "The Smart Cities Mission" in June 2015 with the goal of creating 100 "Smart Cities" in five years (by 2020). This mission was a joint effort of the Ministry of Housing and Urban Affairs (MoHUA), and all state and union territory (UT) governments. People, governments, intellectuals and urban planners all have different definition of what constitutes a "Smart City", while the government has yet to define it. The Smart Cities Mission Statement and Guidelines suggest that a "Smart City" will have the following elements: adequate water supply; reliable electricity; sanitation & solid waste management; efficient public transportation; affordable housing; strong IT connectivity and digitalisation; good governance; sustainable environment; citizen safety and security; and health and education.

The development strategy of the Smart City Mission is Area-Based Development (ABD) and Pan-City development where it involves selecting areas of specified size like 50 acres for redevelopment, 500 acres for retrofitting and 250 acres for Greenfield development. The Pan-Development Proposal is for the entire city using innovative and smart solutions to improve the city's infrastructure.

City-wide planning isn't the only thing that makes a city smart. It also includes Smart solutions within an inclusive policy framework which are more important than Smart Cities. All the cities that have smart (intelligent) physical, social, institutional and economic infrastructure are referred to as Smart Cities. It is believed that such a Smart City will provide opportunities to ordinary people to pursue their livelihoods and interests in meaningful ways.

Figure-1.1: Location of the Canal Corridor with Linear Park
Source: Adopted and edited from Google Earth Map 2022.

1.1 Topic and Context

The Canal Corridor Development projects were taken up by the Surat Municipal Corporation. The aim was to improve the present unhealthy conditions prevailing along the existing canal and to have maximum utilisation of the road width within the city, and to build such an environment along the canal road which would not only improve the corridor but will also create an environment-friendly atmosphere for their smart citizens. The present project deals with the development of a 60-m wide and 3-km long canal corridor from Anuvratdwar Junction to Jamnaba park in South-West Zone in the city. (Figure 1)

The basic idea was to ensure that the existing space around the present canal is converted into sufficiently wide road for transport mobility with pedestrian safety and also develop a walkway with suitable landscape on either side of the canal. With a full stretch of more than 100-feet wide greenbelt, which goes along the total length of the road more than 2500-m and provides a healthy environment full of local species of plants, flowering plants, medicinal plants, etc and also recreational facilities such as play areas and gathering places for citizens, wherein they can get a recreational spot in their own neighborhood. This road will also prove to be a leisure activity area for kids and senior citizens with a lot of greenery and happening places.

This project focuses on building a landscaping environment and road safety as well, which in turn will prevent accidents and provide a health recreational environment to the citizens.

1.2 Significance of the project

Surat is among the most active cities of India, with a considerable migration of people from Gujarat and neighbouring regions. Surat Municipal Corporation (SMC) launched the landscaping initiatives in collaboration with GIZ. Tree plantation is a great approach to improve the environment while also minimising air pollution at the same time. The initiative started mostly with identification of carbon emission zones/pollution areas followed by the planting of trees in certain areas.

The Canal Corridor and the Pandesara Industrial Estate were designated as two hotspots of the project. For the selected hotspots, a landscaping design was produced as drawings. In addition, a 'Plant Catalogue and Plant Palette' was created to give information about the native trees and to help in the planting of trees in Surat.

SMC selected the categories of air pollutants that should be addressed and estimated the amount of pollution that will be reduced. They also suggested plant types for plantation to help with pollution mitigation in Surat.

To increase the canopy cover, SMC planted a large number of trees and did a huge amount of agroforestry and horticulture in the peri-urban areas of the city. This initiative used a two-pronged strategy: planting and rigorous monitoring. As per analysis, a total of seven to eight lakh trees were needed wherein roughly two lakh tall saplings were planted in accessible areas along the Tapi River, canal corridors and other institutional lands.

1.3 Aim and Objectives

This research aims to critically review the Canal Corridor with Linear Park Development under the Surat Smart City Mission.

The objectives of the study are:

i. To critically review the Canal Corridor Project and to understand its sustainability under the ABD, its formulation with various implementation mechanisms and financial sources.
ii. To analyse the project's economic viability based on ecological and physical impact in it's surroundings through planning and design, spatial time-line, land use, built use, built-un-built spaces and real estate market trends.
iii. To analyse the project's liveability based on sociability, economic activities, comfortability and connectivity from both tangible and intangible aspects.
iv. To provide constructive feedbacks and suggestions if needed for better efficiency (Performance) & implementation of the project in future.

2. Contextual Background

Surat city defines the mobility vision as 'SARAL' which stands for Safe, Accessible, Reliable, Advanced and Low-carbon mobility. Surat is known for its vibrant culture and economy majorly in diamond and textile industries. Its strategic location between Mumbai and Ahmedabad and proximity to the proposed DMIC (Delhi–Mumbai Industrial Corridor), provides it the potential to develop as an economic powerhouse of Gujarat.

The inspiration for developing the canal came from Diamond and the textile hub. The vibrant colours from the textiles inspire the elements in the park. These colours within the set-up of green vegetation and blue canal water, tries to bind the whole stretch as a thread weaves together to make a fabric.

The Canal Corridor Development Projects were taken up by Surat Municipal Corporation to improve the present unhealthy conditions prevailing along the existing canal and to have maximum utilisation of the road width within the city, and to build such an environment along the canal road which will not only improves the mobility on the corridor but will also create an environment-

friendly atmosphere for their smart citizens. The present project deals with the development of a 60-m wide and 3-km long canal corridor from Anuvratdwar Junction to Jamnaba Park in the South-West Zone of the city. (Figure 2.1)

SMC has developed recreational zones along the canal road with landscape on either side which incorporates facilities such as street furniture, park, children's play area, canal crossings and parking facilities etc.

The basic idea was to ensure that the existing space around the present canal is converted into sufficiently wide road for transport mobility along with pedestrian safety and also develop a walkway with suitable landscape on either side of the canal. With a full stretch of more than 100-feet wide greenbelt, which goes along the total road length of more than 2500-m providing a healthy environment full of a large number of local species of plants, flowering plants, medicinal plants, etc and also recreational facilities such as play areas and gathering spaces for the citizens. The road will also prove to be a leisure activity area for kids and senior citizens with a lot of greenery and happening places.

This project focuses on building a landscaped environment with road safety, which in turn is expected to prevent accidents and provide a health recreational environment to the citizens.

2.1 Conceptual Framework/Research Design

2.1.1 Descriptive theoretical background, literature review and case studies - Smart City Mission, waterfront and linear park definitions, need for canal development, general principles of waterfront development, advantages and benefits, place and place-making.

2.1.2 Analytical Framework - Analytical framework for the Canal Corridor Development through four parameters such as sociability, uses & economic activity, comfort & image and access & linkages.

2.1.3 Practical and Analytical Approach - Data collection through documentation and evaluation of the existing recently developed Canal Corridor project in Surat City. This project will be studied in reference to the selected parameters which will investigate in detail the intangible and tangible indicators through qualitative and quantitative measures.

2.1.4 Final Data Analysis and Critical Review - Assessment frameworks and Critical Impact Assessment through findings, implications of physical, social and ecological followed by key learnings from the project and recommendations on various aspects of the project.

2.1.5 Literature Review

Public open Spaces and Sustainable Development Goals

"Public spaces, which are the core of urban regions, are an essential component in creating cities that are inclusive, healthy, functional and productive. They can help the city achieve long-term sustainability by delivering environmental, social, economic and health advantages. Public open space has been recognised as a particular target under the 11th SDG to assist in developing safe, inclusive, resilient and sustainable cities." (SDG, 2019)

The chart depicts the significance of public spaces to add value to a number of long-term development goals. The SDGs linked to public places are represented by the wheel's innermost circle. The centre circle indicates the particular SDG targets that may be met through the development of public spaces. The advantages are shown in the outermost circle based on three types of public areas: markets, open spaces and streets. Outside the wheel, the proposed activities to achieve these outcomes are linked to the corresponding SDGs. (Figure 2.1.1)

What Makes a Public Space Successful?

An excellent public place could be used for a variety of purposes. Why are some places successful while others are not? The Project for Public Spaces has reviewed thousands of public spaces throughout the world and discovered that effective areas have four similar qualities: Accessibility and community connection, a stimulus for activities, opportunities for social interactions and comfort.

The Place Diagram was created as a tool to analyse public space by The Project for Public Spaces in response. The four criteria in the orange ring can be used to evaluate the centre circle if it is a specific location. Outside of those requirements, there is a variety of intuitive or qualitative considerations to consider while evaluating the place. The outer ring contains quantifiable elements that may be measured. (Figure 2.1.2).

2.1.6 Case Study: Xuhui Runway Park, Shanghai, China, 2020

"Xuhui Runway Park is an innovative urban revitalisation project that breathes life into a unique piece of Shanghai's history." ("Xuhui Runway Park – Sasaki," 2020)

"With the recent redevelopment of the Xuhui Riverfront Area into a mixed-use district, the historic runway is embracing its new life. Master planned as a public street with a linear park, this project serves as a runway of modern life, offering a recreation space for the nearby communities, as well as respite from the high-density redevelopment around. Following its environmentally, socially and economically sustainable approaches, the site will lead the city's new lifestyle." ("Xuhui Runway Park – Sasaki," 2020)

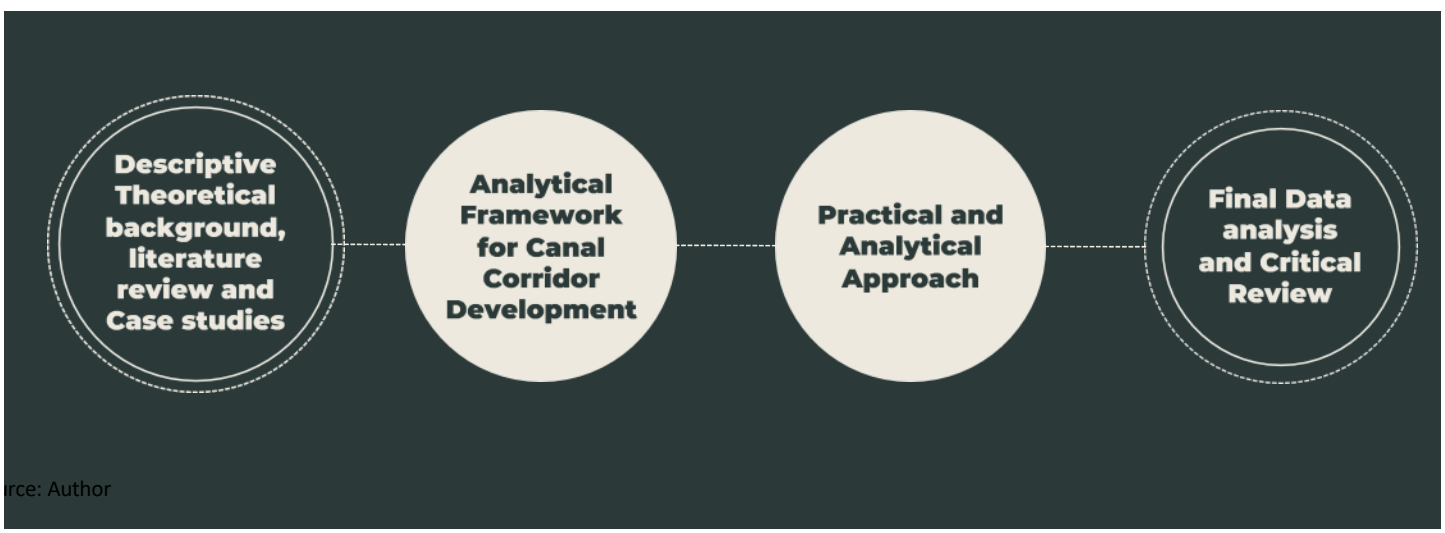


Figure-2.1: Research Methodology
Source: Author

Figure-2.1: Nollie's Map of Canal Corridor with Linear Park, Surat.
Source: Google Earth - Snazzy Maps 2022

"The layout of Yunjin Road contributes to a compact urban district by limiting the number of vehicular travel lanes and promoting public transit over personal cars. Designated bike lanes have been integrated into the street section, facilitating the "last one kilometer" commute between the transit and individual destinations. Additionally, six rows of deciduous trees are planted along the sidewalks, bicycle lanes and road median, creating a comfortable microclimate, seasonal effects and a human-scaled boulevard." ("Xuhui Runway Park – Sasaki," 2020)

2.1.7 Case Study: The Public Parks and Garden in Surat

Out of the 326 sq km, 2.63 sq km are now covered with parks, gardens and open areas. Only 0.8 percent of the SMC's overall area is devoted to this. Parks and open spaces are catered for at all levels, including the neighborhood, city and community. Parks and open spaces are in short supply at SMC and across the Surat Urban Development Area (SUDA). As a result, efforts should be made to enhance the space beneath them and to provide people with a green and healthy atmosphere.

Figure-2.1.1: Coherence of SDGs with Public Open Spaces: Targets, Actions and Benefits
Source: SDGs - Sustainable Development Knowledge Platform. 2019.

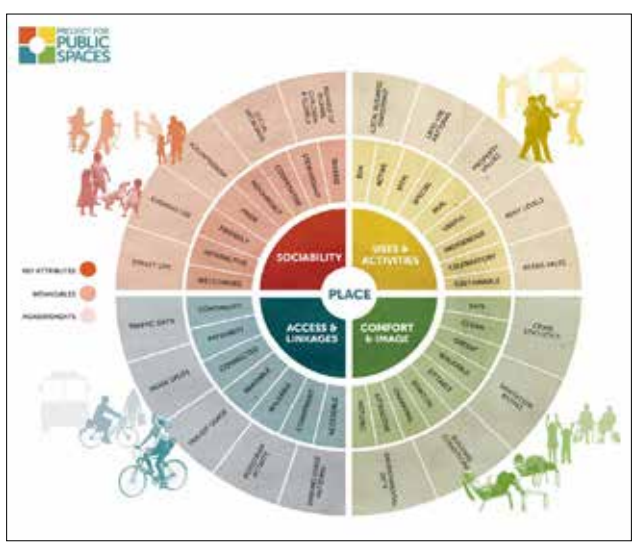


Figure 2.1.2: Diagram representing what makes a great place?
Source: Playcore : Building Communities through play and recreation. 2022

There is no formal procedure for the creation of new parks and open spaces in the current developed areas. Over the last decade, the quantity of open spaces available in the city has steadily decreased. At present, the available recreational facilities are insufficient to meet the demands of the people. The city's parking facilities for parks and open areas are also insufficient.

2.2 Key features of the project

2.2.1 Challenges in the project

- Bringing about a more equitable allocation of road space for citizens rather than just converting the road space into a vehicle mobility corridor.
- Improved access and mobility for all citizens at all times by providing necessary safe and usable pedestrian facilities which will be well designed with attractive street furniture and which are maintenance free.
- Providing some walkable space for citizens along with a healthy environment.
- Providing recreational spaces for all age groups, play zones, linear park, on-street as well as designated parking spaces. Safety of pedestrians all along the road.
- Better visibility using LED fittings and attractive spaces using sculptures, frame bridges, deck spaces over the canal.

2.2.2 Risks involved in the project

- The physical characteristics which park users associate with high-risk environment include: Poor lighting, confusing layout, physical and aural isolation, poor visibility, no access to help, areas of concealment, poor maintenance, vandalism and presence of undesirable elements.
- In the initial stages of project execution, public parked their vehicles on any side of the park and created traffic nuisance around the site work which hampered the project in terms of time and execution of the work.
- Developing the Canal Corridor with Linear Park in this area for high-profile society

Figure-2.1.3: Runway Playground and Streetside Rain Garden
Source: Xuhui Runway Park – Sasaki, 2020

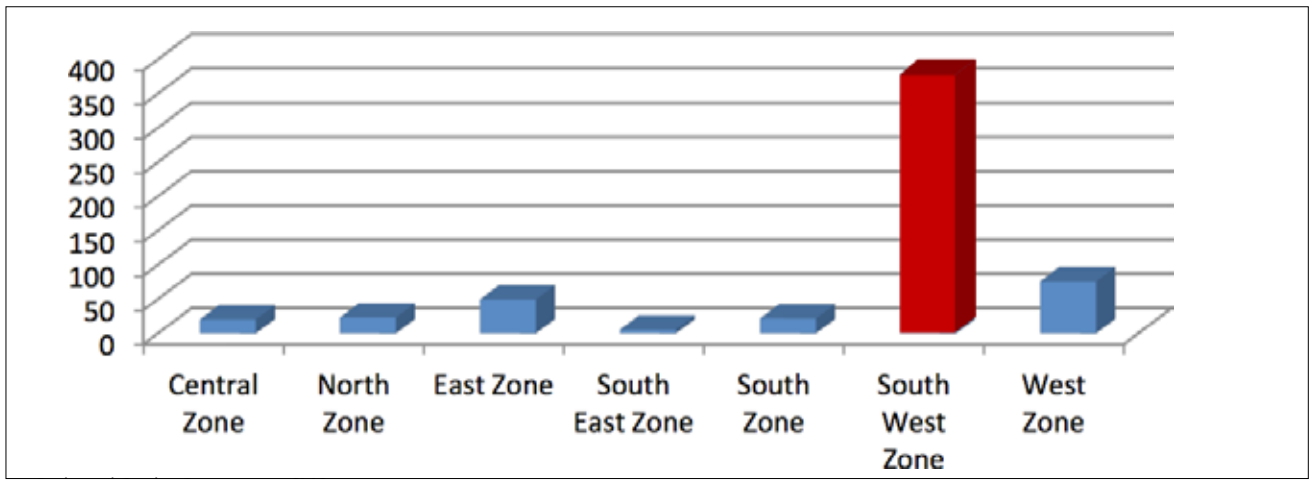


Figure-2.1.4: Zone-wise parks and garden spaces available in sq m per population of 100
Source: Parks and Garden Department, SMC

keeping in mind that they will utilise this park very efficiently and there won't be any negative issues. But this was not the case here, whether it is developed in Vesu or in any other part of the city, the issues would have remained the same.

- Due to fund restrictions and other limitations, it was planned to first develop only 3-km instead of developing 6-km in a single instance.

2.2.3 Features and Benefits (social, technical, city administration level, impact on environment and economy) to the city (expected and observed)

- There was a partial one side road along the canal with encroachments and degenerating conditions. The linear park is yet to operationalise on this stretch and the transformation of the adjoining land-use, up-gradation in land prices and densification are apparent.
- Canal beautification project will provide more recreational area to people. This will improve the overall environment of the surrounding areas and also improve the health of the people.
- These projects are focusing on landscaping and safety which will reduce accidents and improve the environment of the city. Directly or indirectly this project will be beneficial for the citizens of Surat.
- Beautification will lead to improvement in the surrounding environment. The total road project was completed within 22 months on 29/02/2020 at a project cost of Rs 54.41 crore.

2.3 Key findings from interviews, surveys and primary/ secondary data collection

2.3.1 Demarcating Boundary Line based on Block Perimeter

To study the impact of the Linear Park in its immediate surroundings five consecutive radii of 100-m were considered upto 500-m. Based on the overlapping marked radii, the first block perimeter was considered as a study area for impact analysis. Presently, 2.3-km is the actual length and 60-m width of the Linear Park development along the canal corridor. The total boundary area/block perimeter area around the canal corridor is 3.1-sq km. The total green open spaces which contribute 4.19% of the total boundary marked area which is 130303 sq m (0.13 sq km).

2.3.2 Time-line of the Physical Transformation and Urbanisation effects

The spatial growth of built-up areas accompanied by changes in the urban spatial structure and form is the apparent result of land use change in the wake of urbanisation. Increased population leads to increased land demand which has ramifications for users of natural resources like water bodies and open spaces. It is important to convert water bodies and open places to sustain urbanisation. It is necessary to evaluate not only the area of the land converted to urban use, but also the prior land use and land cover, the major purpose of the new urban use, the associated land cover features, the location and pattern of new urban land and land use efficiency. The site surrounding upto year 2005 has not seen much spatial growth since there were only VNSGU University and Dr Hedgewar Nagar - an old residential society to the west of the Canal Road and a newly developed EWS housing towards the right. Later, around 2011, this area saw significant growth with new private institutes and a boom in residential demand. Since the past one decade the development around the canal corridor has witnessed huge growth in residential construction. This is because of the canal corridor development, the proposed international airport, Dream city, metro and Hazira Industrial Park which will be built in the near future and is expected to increase the demand for real estate.

2.3.3 Land Use surrounding the Canal Corridor with Linear Park

During 2000-2021 the urbanisation in this area increased considerably, almost four times, from an agricultural and institutional land to a full-fledged high-end mixed use neighborhood. The existing land use prepared from different layers of the present TP schemes along with Google Earth imagery as base map, drafted over CAD is being used to analyse the existing situation of development within this block perimeter.

The canal corridor has total 4% of Green open space, 1% land under water bodies, 2% land as agricultural and 8% land for roads. This area has 24% maximum Institutional land followed by 23% as residential land use. It also has 23% as vacant land which has high potential for development in the future.

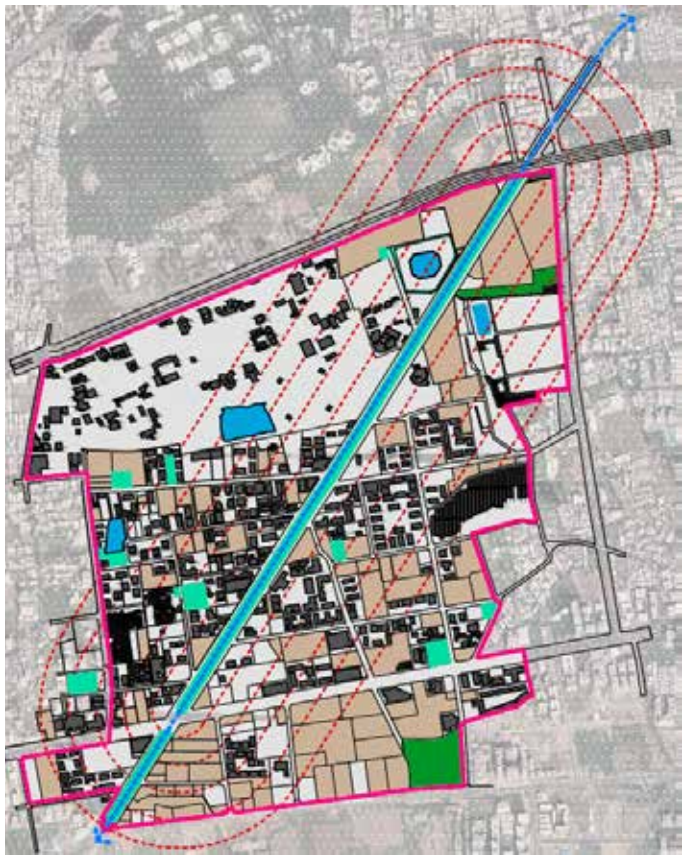


Figure-2.3.1: Demarcating the final boundary along the Canal Corridor
Source: Author, 2022.

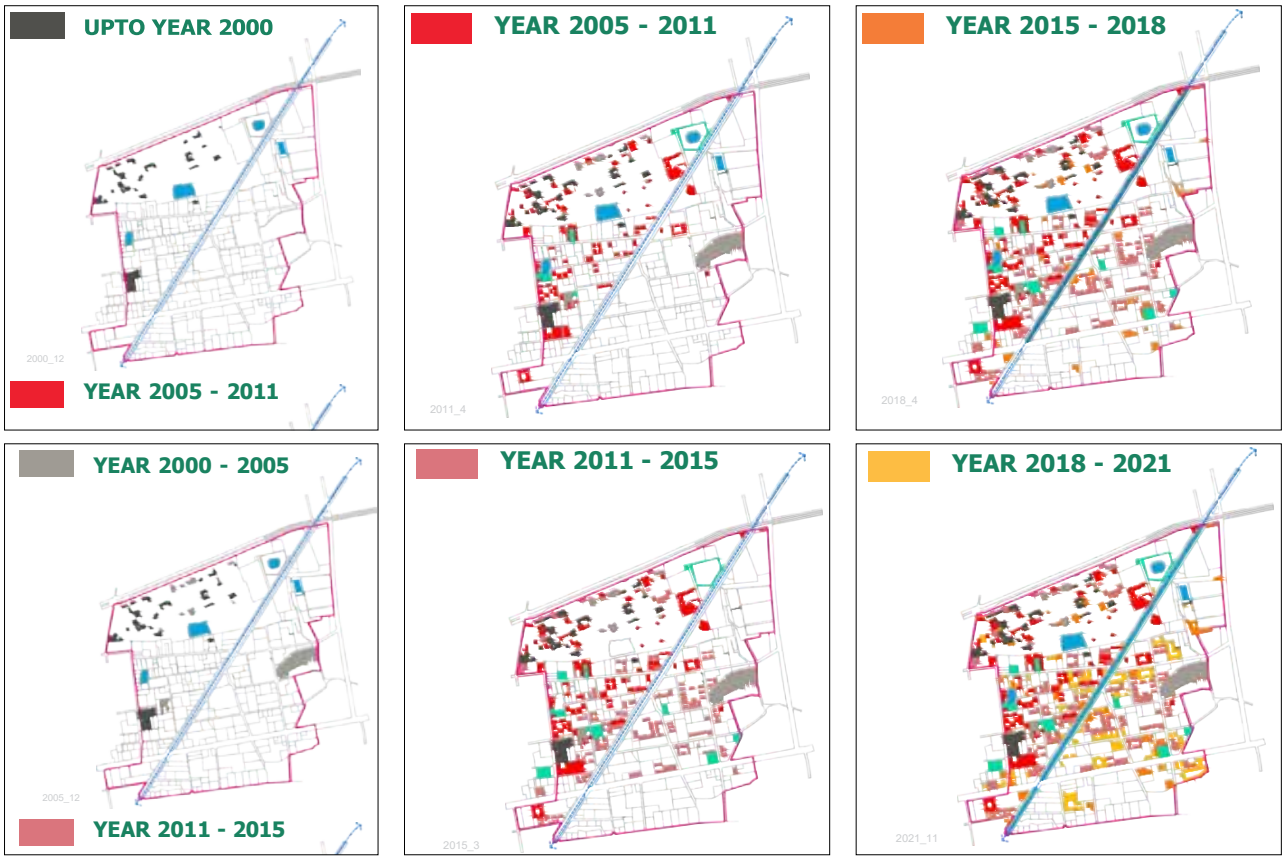


Figure-2.3.2: Spatial growth along the Canal Corridor with Linear Park
Source: Author, 2022.

2.3.4 *Built Vs Un-built Ratio*

As per the selected block perimeter, the total built-up is only 12.3% as compared to the total un-built open spaces which is 87.7%. These un-built spaces along the canal corridor are further classified into - 4% Green open spaces, 1% water bodies, 2% land for agriculture, 8% total land area under roads and streets, 49.7% area under margins and setbacks and 23% total land area as privately owned vacant land.

2.3.5 *Real Estate Market Trends*

The development of a Linear Park has boosted retail activity and property values in the region. The areas around the recently opened Canal Corridor with Linear Park have seen a surge in demand for upscale and premium real estate as well as rise in the number of commercial, mostly new restaurants and retail outlets.

As compared to the other locations of Surat, the Canal Corridor with Linear Park is a newly developed area in the city with good quality physical and social infrastructure making it an attractive destination for Higher Income Groups (HIG) population. This locality comprises of high-end luxurious and premium residential development. It also comprises of a mix of prime commercial offices and plazas. Majority of diamond traders and textile merchants resides in this area.

2.3.6 *Survey Sampling*

The collective view of the local visitors, residents, shopkeepers, workers, supervisors, etc directly or indirectly connected to the park who were interviewed at every 500-m distance of the Linear Park was noted. Almost 98 survey samples were collected considering various users irrespective of their gender, age, profession, caste, religion, etc. From the survey it was found that there were about 57% males and 43% other responders where 65% were within the age group of 18-25 years. The highest responses were observed from the Anuvratdwar Junction contributing to 68% indicating that this area is highly utilised and easily accessible

A. *How Sociable is the Place?*

Sociability is dependent on the interaction of people amongst themselves, intentional or induced. If the linear park is a good place to meet friends and relatives, if a diverse user group with diverse activities is present, if people use a particular place by choice, if the sidewalks are wide enough for activities to happen and are welcoming then one can say that the Linear Park is sociable and has the ability to attract people. About 78% users think that this park is a good option for meeting friends and spend quality time with family. People use this park regularly and by choice because of a wide range of amenities provided which include walking, jogging and cycling tracks, aerobic lawns, meditation areas, flower-park, dog-park, School art gallery, children's play area, amusement park, sports court, outdoor gym and practice nets. Almost 86% users accept that there are diverse activities for different user groups. Nearly 69% of the people feel that due to these activities the sidewalks have become attractive and welcoming.

B. *Does it have a variety of uses and activities that people can be engaged in?*

On the Canal Corridor diverse activities are present. Of the users, 59% feel that there are more than two to five activities and 26% users feel that there are more than six to ten activities to do along this Linear Park.

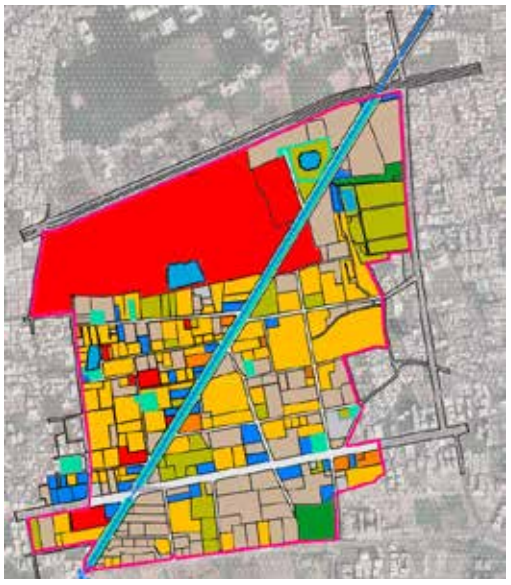


Figure-2.3.3: Land Use surrounding the Canal Corridor with Linear Park
Source: Author, 2022.

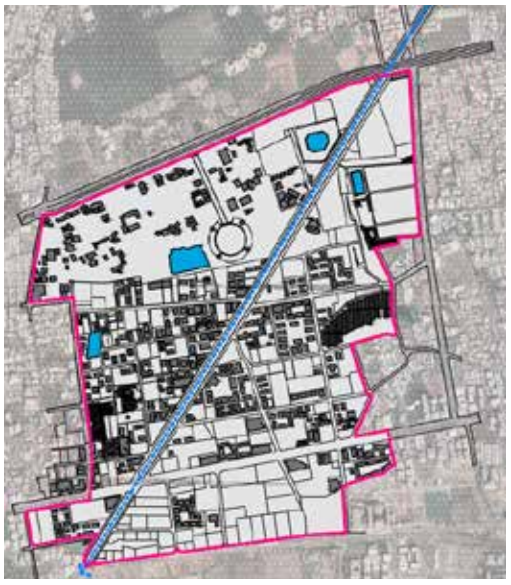


Figure-2.3.4: Built and Un-built spaces surrounding the Canal Corridor with Linear Park
Source: Author, 2022.

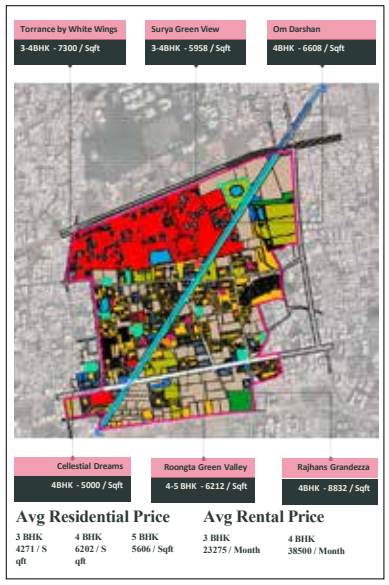


Figure-2.3.7: Price Trend for Apartment around Linear Park in Vesu, Surat
Source: Primary and secondary market survey by author, 2022.

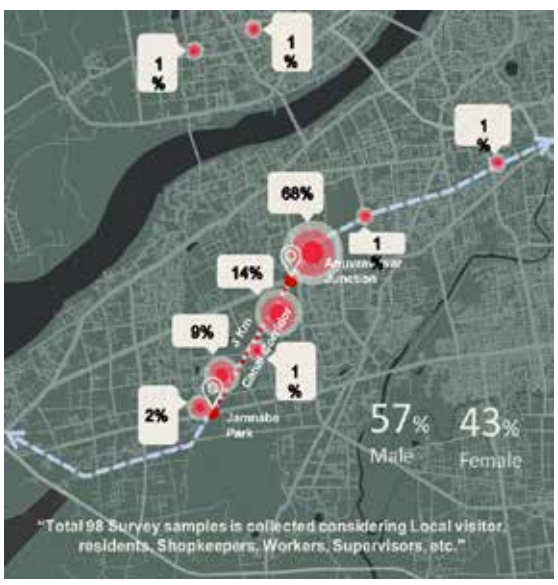


Figure-2.3.8: Site Survey Samplings
Source: Author, 2022.

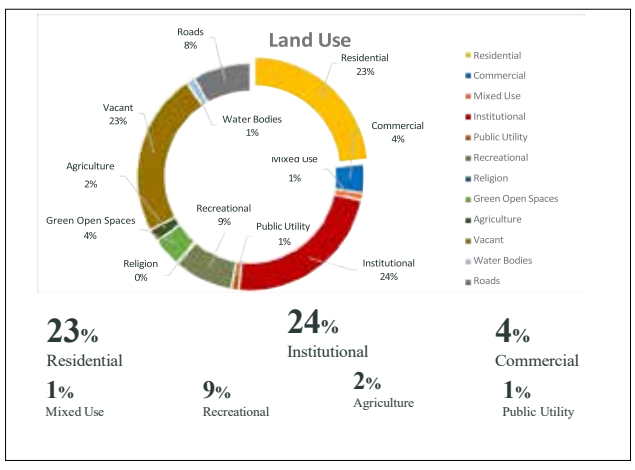


Figure-2.3.4: Built-use of the site
Source: Author, 2022.

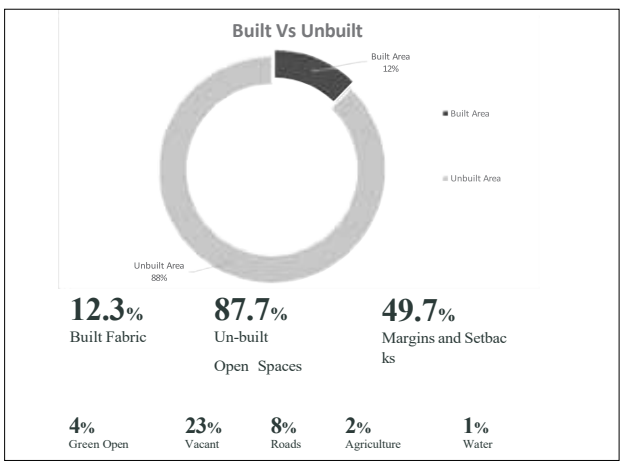


Figure-2.3.5: Built Vs Un-built
Source: Author, 2022.

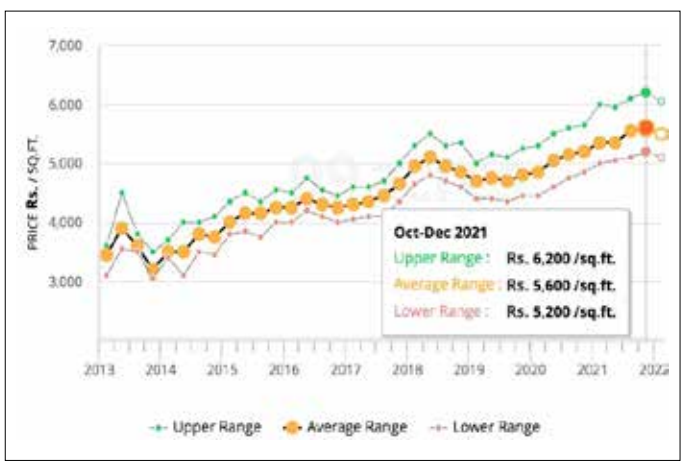


Figure-2.3.6: Residential ticket sizes and prices around Linear Park in Vesu, Surat

The park offers different types of activities such as walking, eating, playing cricket, football, skating, chess, relaxing, reading, etc. Liveable parks are important to attract people. When people come to enjoy along the Linear Park, they usually come in groups. This is a good thing as the presence of people attracts more people. Activities and usage is the sole factor responsible for drawing people to the park and along the canal corridor. About 74% people come to the canal corridor and linear park in groups of two to five, whereas only 11% of them come alone and this gives a feeling of liveliness around the linear park. Nearly 62.2% people feel that there is no proper management, however, at present Tejas Publicity has taken over the area.

C. Are these places comfortable, welcoming and have a good image?

The first impression of the Linear Park is important according to the users since it determines the frequency of their usage. Approximately, 30% of the people say that the first impression of the park is extraordinary while 65% say that it is good because of the environment, liveliness, crowd and multiple options to explore. According to 32% of the people surveyed, the Canal Corridor is occupied by vehicles during the day and is dominated by pedestrians, whereas, 47% say it is not a problem. In terms of places to sit and spend time, 84% people experience that there are enough places to sit and spend time along the park. Sidewalks are also available, so 60% people approve that this canal corridor is safe to walk and 62% users said that it is safe even at night as there are street lights. Almost 51% said that sometimes there are more women than men. This corridor connects the rest of the city with Vesu - VIP Road, the city's most popular residential, business, retail and development destination, keeping it alive throughout the night as well.

D. Is this place well-connected and accessible to the surroundings?

According to the users the Canal Corridor is well accessible and well-connected to Vesu-VIP Road at the lower end and to Anuvratdwar Junction at Udhana-Magdalla Road at the upper end. The Canal Corridor is widely used as a Non-Motorised Transport (NMT) where city buses and heavy vehicles are not permitted. There are no specific transit stops along the corridor but they are located at appropriate places, near Anuvratdwar Junction (West) BRTS. This road is also well-connected to other roads and is properly linked through public transport like city buses and BRTS. Most people use private vehicles with 30% using two-wheelers and 21% using cars. As per the survey, frequency and availability of public transport is low with just 13%, encouraging the use of private transport. This has a negative impact on the accessibility of the Canal Corridor with the Linear Park.

3. Discussion and Conclusion

3.1 Implications

3.1.1 Physical Implications

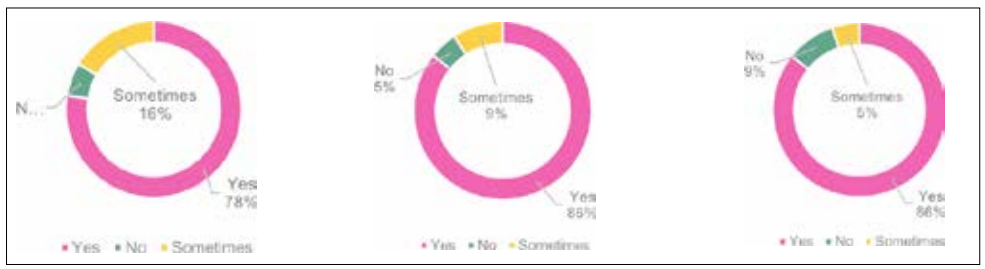
The outcome of the project is the creation of a formal sport, preservation of the natural environment, improved quality of life, making the city and its people healthy, promoting social contacts, curtailing greenhouse emission and helping in lessening global warming, making living attractive and viable, increasing ground water charging, ensuring biodiversity and promoting wildlife habitat, increasing symbolic cultural value and very important, creating economic opportunities in the city. The present development has a significant impact on the surrounding areas in terms of mixed land use, use of built-up area with enhanced physical infrastructure, more of open spaces than other areas of the city, real estate market, mobility and NMT.

During 2000-2021, the urbanisation in this area increased considerably, almost four times in terms of high-end mixed land use. As per the SDG indicator 11.7.1, "An average share of the built-up area of cities that is open space for public use for all by sex, age and persons with disabilities" is 7.13% of the built-up area around Linear Park that is open space for public use. The development of the Linear Park has a wide impact on its built typology in terms of built-use along the canal corridor which gives it a unique character and visual interest. The development has given boost to retail activities and property values. The neighborhood around the newly opened Canal Corridor with Linear Park saw high demand for luxurious and premium real estate and an increase in the number of businesses, mostly new restaurants and retail stores.

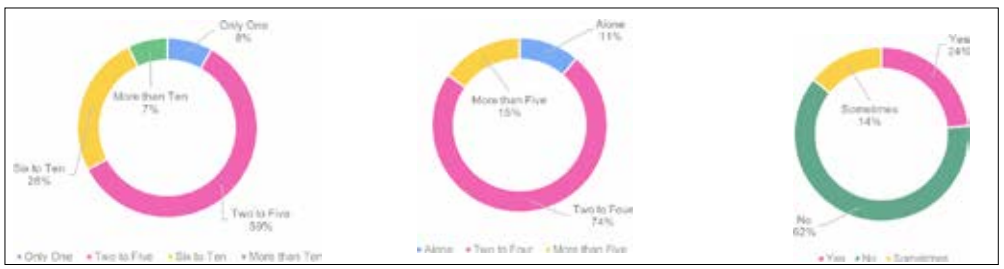
3.1.2 Social Implications

Sociability: Sociability is a very important factor for a successful public space. This is dependent on the interaction of people amongst themselves, intentional or induced. This Linear Park is a good option to meet friends and spend quality time with family. People use this park regularly and by choice because of the wide range of amenities provided. Diverse user groups are involved in diverse activities, the sidewalks are wide for activities to take place and the area is welcoming. Therefore, the Linear Park is sociable and has the ability to attract people.

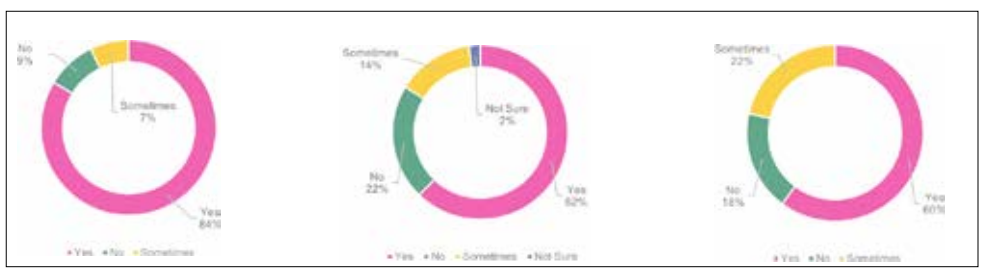
Usage and Activities: The Linear Park brings together people for many activities and help enhance social interaction. Diverse activities from diverse user groups make it a liveable place in the public realm. People use this place regularly and by choice for walking, eating, playing cricket, chess, relaxing, reading, etc. Sidewalks are welcoming as they are active and vibrant with diverse group activities. Liveable parks are important to attract people. People usually come to the Linear Park in



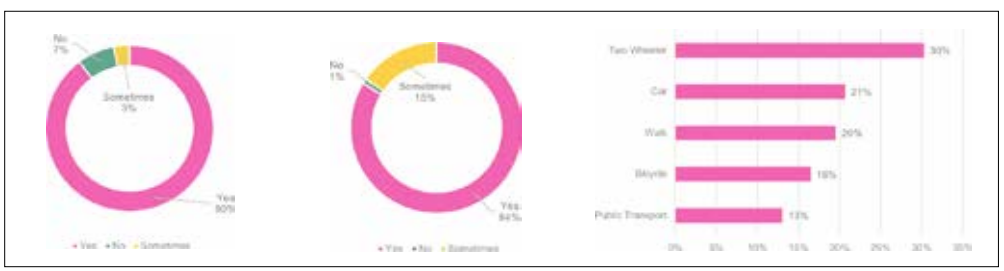
Is this a place where you would choose to meet your friends? | *Does this space reflect a mix of various ages and diverse group activities?* | *Are the sidewalks wide enough and welcoming to walk?*



How many different types of activities occur - people walking, eating, playing, etc.? | *Do you visit the place alone or in a group?* | *Is there any management present or can you identify anyone who is in charge of the space?*



Are there enough places to sit and spend some time? | *Does the area feel safe at night?* | *Is this corridor road safe to cross and walk?*



Is this Canal Corridor and Linear Park connected to main streets? | *Is it easily accessible?* | *What is the mode of Transport to reach this place?*

groups to enjoy. This is a good thing as the presence of people attracts more people.

Comfort and Image: The first impression of the park is extraordinary and good which is very important according to the users as it determines the frequency of their usage. The Canal Corridor is occupied by vehicles during the day and dominated by pedestrians. At times, the high speed vehicular traffic can hamper the safety of the pedestrians. People have enough places to sit and spend some time along the Linear Park. Sometimes there are more women than men where people approve that this corridor is safe to walk and that it is safe even at night due to the presence of street lights. There are issues regarding public toilets, washrooms and drinking water.

Access and Linkage: According to the users' perspective the Canal Corridor is easily accessible and well-connected to major abutting roads. The corridor is widely used as a Non-Motorised Transport (NMT) where city buses and heavy vehicles are not permitted. Most people use private vehicles to reach this place as frequency and availability of the public transport is low, which has a negative impact on the accessibility. Attention is needed to lower the height of the railing along the road side with people entering the park over these railings which can cause accidents.

Concerns for Project Affected People – Undesirable Elements and Urban Poor: The main purpose of the project is to address the issue of many illegal residential activities which are being developed along the banks of the creeks, rivers and the canal's empty lands. This project was selected as it was decided to limit these activities and the further spread/encroachment on Government's land. Before the development of the park, there were settlements of homeless people and slum dwellers who resided on this open space along the canal. But when this development was completed all these dwellers occupied the area under the Anuvratdwar Flyover and a patch of vacant land near Anuvratdwar Junction and no measures have been taken regarding these settlements.

3.1.3 Ecological Implications

The Canal Corridor with Linear Park is a fine example for one of the most important ecological spaces in the city which is an initiative taken by the Surat Smart City Mission to strengthen resilience by helping to improve the surrounding area. Since urbanisation causes agricultural land to be converted to urban use, it has a negative impact on the natural and environmental resources. The main challenge for cities is to urbanise without reducing the amount of green cover. The preservation and development of green places in the city such as the Canal Corridor with Linear Park, promotes quality of life and protects the quality of basic resources like air and water.

The Canal Corridor with Linear Park also contributes in reducing carbon emission, urban microclimate maintenance, air and water quality improvement, noise pollution buffering and environmental conservation. The ecological, physical habitat, social and economic impact of the Linear Park as a public space can all be taken into account. This park has not only improved the people's quality of life, but it also acts as a natural shock absorbent and minimises the urban heat island effect by lowering surface air temperature.

3.2 Limitation of the Research

i. The scope of this research was to understand the factors which govern the public realm of the public park.
ii. This research is ethnographic and exploratory by being qualitative, quantitative and literature based.
iii. This research is based on the urban public place - Canal Corridor with Linear Park of Surat city.
iv. The study was carried out through multiple site visits before a private agency called Tejash Publicity took over the maintenance of the park.
v. The study is broadly based on the literature review, stakeholder interviews, data collection from documentation and observation of the Canal Corridor in the present context. The findings will be reinforced with the primary user's surveys.
vi. Special analysis of the existing parks and public open spaces was done as per the SMC data and information available from primary and secondary study.

3.3 Key Lessons Learnt

This analysis throws light on the key factors that are at times, overlooked in favor of specific attributes and their related tangibles and intangibles for making this public place sociable. The sociability of the public place is dependent on a good public realm. The sociability of a park is a combined result of accessibility and linkage, usage and activities taking place along the Linear Park, comfort and image experienced by the user and most importantly, social interactions and social inclusion within the park.

This research will be useful in understanding the physical, social and ecological aspects of the public place and the findings will be useful in understanding the attributes which help evaluate a public place efficiently. World-wide initiatives have been taken to make public places liveable and more sociable. This research is an attempt to analyse public places in the Indian context and to identify the factors responsible for the public realm in the Linear Park.

The importance of physicality, sociability and ecology along the public realm of the public place is undeniable and must be incorporated with due diligence. This research will help to make "A PUBLIC SPACE SUCCESSFUL" by achieving a balance between different realms, mixed amenities and activities along the public realms. These findings can be taken forward by planners, architects, landscape designers and transport designers while designing great public spaces in any city.

3.4 Recommendations

3.4.1 Scalabilty of the project within Surat city

The rules for providing open space under the UDPFI and TP schemes are for comprehensive provision which do not include crucial recommendations on issues like open space distribution and catchment, minimum space criteria for open spaces and everything else. It only recommends that an open space is kept on 5% of the

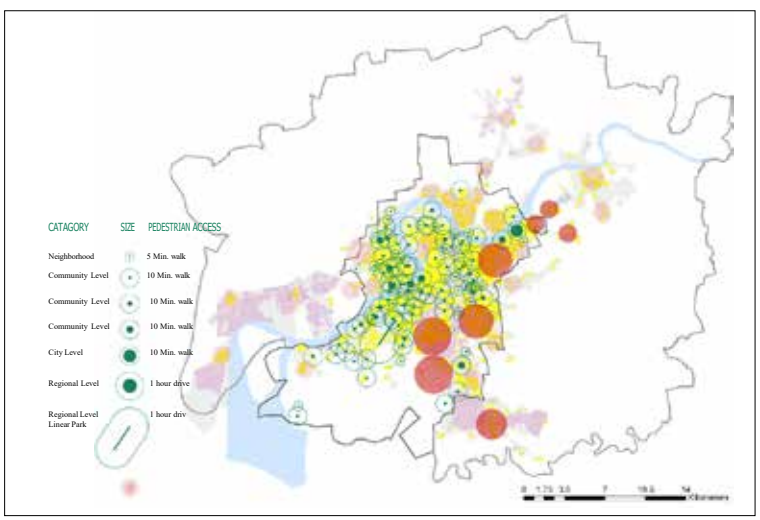


Figure-3.1: Proximity of Open spaces in Surat City
Source: Author.

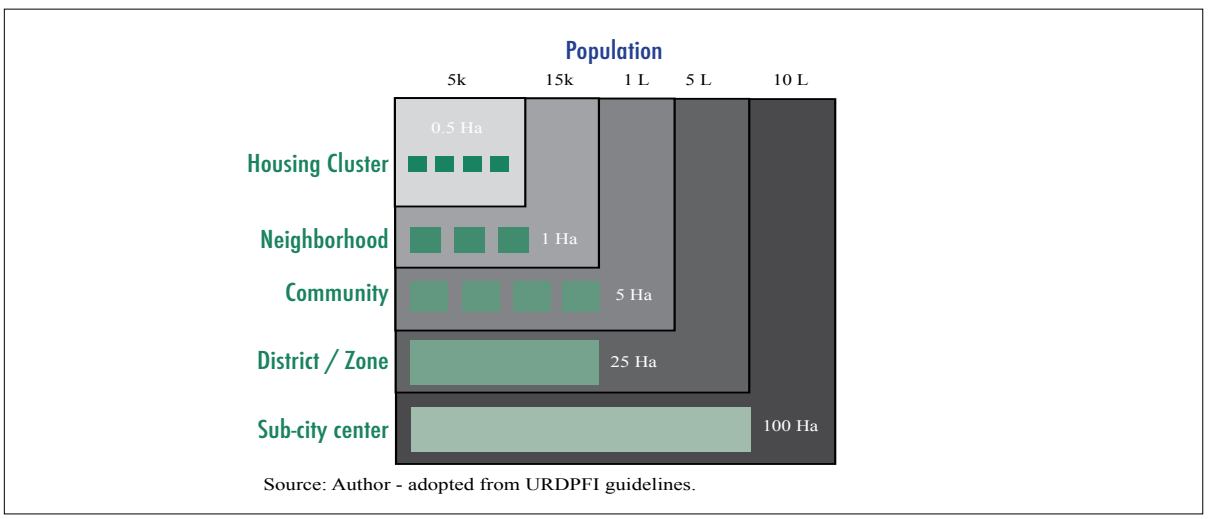


Figure-3.2: URDPFI Guidelines for accessibility parameters for green spaces

overall TP scheme area. There is no formal procedure for the creation of new parks and open spaces in the current developed areas. Within SUDA's jurisdiction, there is no dedicated financing for the development and improvement of parks and open spaces. Over the last decade, the number of open spaces available in the city has steadily decreased. Currently, the recreational facilities available to meet the demands of the people are insufficient.

Out of the 326 sq km, 2.63 sq km are now covered with parks, gardens, and open areas. Only 0.81 percent of the SMC's overall area is devoted to this. Parks and open spaces are included at all levels such as the neighborhood, the city and the community. Public parks and open spaces are in short supply with SMC and across the SUDA. As a result, efforts should be made to enhance the space beneath them and provide people with a green and healthy atmosphere. Some of the landscape deficient areas of Surat have been identified around major abutting residential land use which is marked in red circle, where there is high potentiality for provision to give the green spaces back to the people of the city (See figure 3.1). Gardens and recreational use might be proposed for the land surrounding the existing entire stretch of the canals, lakes, ponds and at Tapi river. The TP plans can provide gardens and open spaces at the neighborhood level. In the North-East part of Surat, total eight recreational places have been suggested due to the big size and potential population expansion in the SUDA region. The majority of the recreational places are proposed in Surat's southern region with others in the city's eastern region.

3.4.2 Replicability in other cities

Other cities which already have such canal corridors or any other similar un-used open spaces can adopt this Canal Corridor with Linear Park model of development and implement it to make it a successful project. This model also refers to the existing guidelines, policies, Acts and rules of their respective states and cities. According to the URDPFI guidelines, urban areas should have 10-12 sq m of green space per person and 1.2 to 1.4 hectare of green space per 1000 people. This is in accordance with the WHO guidelines, which recommend that each individual should have 9 sq m of urban green space. According to WHO criteria, an optimal quantity of urban green space for each person is 50 sq m. The URDPFI standards also recommend accessibility parameters for green spaces which should be between 5-15 minutes of walking distance, or 300-500 m.

3.4.3 From Sustainable Development Goals (SDGs)

Parks and green spaces such as Canal Corridor with Linear Park, provide locations for children to participate in active play and adults to be active during their leisure time. Developing these places to be inclusive for women and girls allows them to fully participate in community life while also contributing to gender equality. Allowing local businesses to utilise these facilities in a secure and comfortable manner adds to it Community cohesiveness is essential for city resilience and public open spaces play an important role in that. Including trees and plants in public open areas in every community adds to climate change resistance and mitigation.

i. **"SDG 3: Ensure healthy lives and promote well-being for all at all ages."**
   a. Create accessible quality public space in urban centers
   b. Create parks in neighborhoods at walkable distance from homes
   c. Create public market where fresh local product is available for communities
   d. Provide streets with separate sidewalks and cycle-lanes along with space for cycle parking
   e. Provide parks and open spaces with high green coverage in urban centres
   f. Make streets pedestrian and cycle friendly

ii. **SDG 5: Achieve gender equality and empower all women and girls."**
   a. Provide clean toilets, gender sensitive areas in parks
   b. Widen sidewalks, improve lightings, ease of access to help in parks, streets and public transportation

iii. **"SDG 8:** Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all."
   a. Protect, preserve and improvise traditional public markets and legalise informal workers
   b. Provide wide sidewalks, exclusive vendor spaces in the parks, transit stations, etc., to improve the walking and cycling environment.

iv. **"SDG 11:** Make cities and human settlements inclusive, safe, resilient and sustainable."
   a. Make parks, open spaces, streets and markets safe, inclusive and accessible

v. **"SDG 13:** Take urgent action to combat climate change and its impact."
   a. Provide parks and open spaces with high green coverage in urban centres
   b. Plant trees in parks and along streets
   c. Make streets pedestrian and cycle friendly and ease access to public markets
   d. Provide open spaces which are easily accessible from neighborhoods

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B2

Critical Review of Dindoli Tertiary Treatment Plant: Surat

Name of the project: *Conservation through Treated Wastewater at Dindoli STP*
Location: *Surat, Gujarat*
Year of Project Implementation: *2020*
Sector: *Climate Change and Resilient Cities*
SDG: *SDG 3.3 and 3.9, SDG 6.3, SDG 11.5 and SDG13.1.*
Project Cost: *Rs. 125 crore*

Institute: *Center for Environment Planning and Technology (CEPT), Ahmedabad*
Advisors: *Dr. Saswat Bandhopadhyay, Dr. Sejal Patel*
Students: *Sayandeep Chakraborthy*

Keywords: *Smart City Mission, Wastewater, Tertiary Treatment Plant, Wastewater Reuse, Sustainable, Sustainable Development Goals*

Abstract:

The research aims to critically review the Wastewater Tertiary Treatment Plant implemented under the Smart City Mission at Dindoli, Surat to document the project design & elements under “Smart cities and Academia towards Action and Research (SAAR)” a joint initiative by National Institute of Urban Affairs (NIUA) and Ministry of Housing and Urban Affairs (MoHUA). The research focuses on analysing how sustainable is the tertiary treatment plant in terms of technical, social, economical and environmental aspects and what value this project adds to the Sustainable Development Goals (SDG).

The key findings from the research show that the tertiary treatment plant is not functioning at full capacity as the outlet parameter of the existing secondary treatment plant does not match with the inlet parameter of the tertiary treatment plant and the produced sludge is not being reused or recycled. Another key finding of the research is the direct contribution to SDG 6, which is Clean Water and Sanitation, target 6.3, and SDG 3, SDG 11 and SDG 13. The study also proposes a few recommendations for proper planning and implementation of wastewater treatment projects, re-cycling and re-use of sludge and a toolkit for process design of tertiary treatment plants.

Case Study: **B2**

1. Introduction

1.1 Topic and Context

The Ministry of Housing and Urban Affairs (MoHUA) inaugurated the "Smart Cities and Academia towards Action and Research (SAAR)" programme under the Smart Cities Mission as part of the Azadi Ka Amrut Mahotsav (AKAM) celebrations on 7th January 2022. It is a collaboration between the MoHUA, the National Institute of Urban Affairs (NIUA), and some of India's top academic institutions. Fifteen prestigious planning institutions and 45 Smart Cities collaborated to document 75 significant projects that are part of the Smart Cities Mission.

The Wastewater Tertiary Treatment Plant implemented under the Smart City Mission at Dindoli, Surat has been selected for critical evaluation under the Climate Change and Resilient Cities category of the SAAR Initiative with an objective to document the project design, its elements and its value addition to the city. The tertiary treatment plant was set-up to supply 40 MLD industrial-grade water to nearby Pandesara Industrial Estate through Surat Municipal Corporation (SMC) by treating the wastewater.

The study's initiative is in Surat, Gujarat's second-largest city by area and population, with the highest migrant population. It is also the economic hub of Gujarat. Surat is one of India's cleanest cities, known as "the silk city," "the diamond city," "the green city," and other such nicknames. Surat, along with Vadodara and Ahmedabad, became more important in the regional context because of its placement at the heart of what is known as the "Golden Corridor" of industrial development. The Gujarat Industrial Development Corporation's (GIDC) industrial complexes at Pandesara, Sachin and Diamond Nagar are on the city's southern outskirts. Surat has faced 60% decadal growth over the last four decades.

Surat is predominantly governed by two authorities Surat Urban Development Authority (SUDA) and Surat Municipal Corporation (SMC). The SMC has a total size of 462.149 sq km. It is divided into seven administrative zones and 101 census wards. Surat Municipal Corporation sees itself as the primary facilitator and provider of basic services to improve people's quality of life. The SMC provides its citizens with safe drinking water, which is extracted from Tapi River and purified at the city treatment plants. In 2010, the water supply achieved ISO-9000-2008 accreditation.

Surat now produces 933 million litres of sewage each day. Approximately 97.5 percent of the city's current population is served by the sewerage system in the city. There are 58 sewage pumping stations and 11 sewerage treatment facilities with almost 1900 km of main sewerage network for sewage collection. Surat's sewerage system is currently served by six drainage schemes, including the sewerage system in the walled city as well as the drainage schemes in the South-East zone, West zone, South-West zone, East zone, North zone and South zone. The schemes, as shown in Annexure 1, serve a total population of 45 lakh (as of Census 2011) via 58 sewage pumping stations and 11 Sewage Treatment Plants (STPs) (Annexure-2).

These STPs have a total design capacity of 1072 MLD. Currently, these STPs process around 900 MLD of wastewater. Surat Municipal Corporation had already commissioned many projects on reuse of Treated Wastewater (TWW) before the policy of Reuse of Treated Wastewater was formulated in 2019. Since 2014, the corporation has been successfully operating a 40 MLD (Net Output) Sewage Treatment Plant at Bamroli based on Ultra Filtration (UF) and Reverse Osmosis (RO) technologies, creating industrial quality water and distributing it to Pandesara GIDC. There has never been a complaint about the quality of treated wastewater and user industries are happy with the quality and quantity of water. Following the successful implementation of the Bamroli TTP, Surat Municipal Corporation initiated a new Tertiary Treatment Plant (TTP) with a capacity of 40 MLD to treat secondary treated water from the Dindoli STP as part of the Indian Smart City Mission in 2017 to supply Pandesara Industrial area with industrial-grade water as the industrial estate requires more of it.

1.2 Significance of the project

The TTP at Dindoli helps Surat Municipal Corporation to conserve fresh potable water by treating wastewater and reusing it for industrial purposes at Pandesara Industrial Estate.

The research questions for the project are:

i. How Sustainable is the TTP in terms of technical, social, economical & environmental aspects?
ii. What value does this project add to the Sustainable Development Goals (SDG)?

1.3 Aim and Objectives

The aim of the project is "To critically review the performance of the Wastewater Tertiary Treatment Plant implemented under the Smart City Mission at Dindoli, Surat".

The objectives of the study are:

i. To document the project design & elements of wastewater tertiary treatment at Dindoli.
ii. To critically review the physical, social, economic & environmental performance of the plant.
iii. To suggest a process design and critical evaluation toolkit for future tertiary treatment plants.

2. Contextual Background

Unfortunately, access to safe freshwater has been increasingly difficult in recent years. All around the world availability of water is under threat because of population growth, climate change and alterations in land and water use. Human forest clearing, rapid urbanisation and others have impacted the water cycle, resulting in a reduction of groundwater recharge, overexploitation of groundwater resources, seawater intrusion and contamination of surface water resources due to the discharge of untreated industrial and municipal wastewater among other things. Water is becoming increasingly scarce in many parts of the world, particularly in developing countries like India.

India is on track to become the world's most populous country, resulting in increased water demands. India's geographical area is around 329 million hectare and it contains 4% of the world's water resources. Even though the average annual water resources potential is 1869 Billion Cubic Metres (BCM), the amount of water that can be used beneficially is much less, at 1123 BCM, due to severe limitations posed by physiography, topography, political issues and the current state of technology to economically harness water resources. India receives over 4000 BCM of yearly rainfall which is more than adequate to meet the country's water needs. However, due to its fluctuation across time and space, only a small percentage of this rainfall is exploited successfully, limiting water availability and available surface and groundwater storage.

Groundwater has been declining at an alarming rate in India which is expected to surpass China as the world's most populous country in less than a decade. More than a third of India's population lives in water-stressed areas and this number is expected to grow due to depleting groundwater and rising urbanisation. India is one of the 17 countries facing extremely high water stress, according to a recent report by the World Resources Institute.

Water problems in India mainly comprise a spatio-temporal variation of water resources leading to lesser water availability even for the present population, exhausting surface and groundwater resources and highly polluted water bodies. The country is close to reaching its water resources limits with more than 54% of the covered area facing high to extreme water stress (<1700 m^3/yr/person of water availability). The existing water resources are under significant pressure due to high water demand patterns. Based on utilisable resources, according to the 2011 census, for a population of 1.2 billion, the country has only 1000 m^3/yr/person

of water indicating the onset of severe water scarcity in many regions. It has been estimated that by the year 2030, the annual demand will be much higher compared to the available water supply. Research indicates that there will be an expected gap of approximately 50% between water demand and supply.

To manage the current and potential water shortages, water resource planners are looking for alternate sources to supplement the world's finite freshwater resources. The use of recycled or reused water, often known as the reuse of treated wastewater, is one method of addressing this water stress. When considering water reuse, it is critical to clarify three related terms: Water recycling, water reclamation and water reuse. The terms "recycled" and "reused" are frequently used interchangeably. Recycled water is defined as treated residential wastewater that has been utilised more than once before being returned to the water cycle. Reclaimed water is not reused or recycled until it is used. It can be reclaimed and reused but it cannot be recycled unless someone uses it. Water reuse is described as the use of water created from wastewater that achieves an appropriate quality (taking into consideration the health and environmental hazards) for its intended application such as irrigation, industrial or civic (municipal) in general.

2.1 Conceptual Framework/Research Design

The research focuses on analysing how sustainable is the Tertiary Treatment Plant in terms of technical, social, economical & environmental aspects and what value this project adds to Sustainable Development Goals (SDG). The methodology of the research is divided into five stages which cover all three objectives of the research:

Stage 1 - Literature Review and Case Study:
This section of the research includes Literature Review and a Case Study. Major emphasis of this research is understanding wastewater, its definition, kinds and management as well as its role in the SDG. The research also examines sewage treatment processes and technologies, as well as wastewater recycling concepts. Examining and analysing the best wastewater reuse strategies at the global, national and state levels. Suggestions from the top Wastewater TTPs like NEWater Singapore and Bamroli Tertiary Treatment Plant, both of which are technical and cost-effective, have been studied during this stage.

Stage 2 - Identification of Dimensions and Indicators:
During this stage, secondary sources were used to review various documents and assessment frameworks to develop dimensions and indicators for critical evaluation of the TTP. Following a review of numerous documents and assessment frameworks throughout the literature research and case study, four aspects for critical evaluation of the tertiary treatment facility were selected: Environment, social, economic and technical.

These four dimensions have twenty-two indicators which will be used for critical evaluation of the wastewater TTP at Dindoli, Surat.

Stage 3 - Field Study:
This section of the study focuses on stakeholder mapping,

Stages	Source of Data	Analytical Tool	Empirical Evidence Needed
Literature Review & Case Study	Secondary Research	Document Reviews, Case Studies	Critical Review of papers from Google Scholar, Academia, E&U, World Bank, ADB, IFC, Previous thesis and other respectable organisation policies, schemes and programmes
Identification of Dimensions and Indicators	Secondary Research	Document Reviews	Assessment of Frameworks, reports
Field Study	Primary Study	Observations, Stakeholder mapping, surveys, FGDs, Interviews of key informants	ENVIRONMENTAL Energy, pollutant removal toxic substances, odour emission, nuisance and no use of chemicals, sludge production, sludge quality SOCIAL Public safety, creation of employment, local development ECONOMIC Construction cost, operation and maintenance cost, land cost of resources used (mechanical and electrical types of equipment and any value-added) TECHNICAL Performance efficiency, durability, reliability and flexibility, ease of construction complexity
Analysis	Primary Study, Secondary Research	Dimensions & indicators identified	Describing and proposing solutions for concerning issues
Final Assessment	Overall Analysis	Developing concluding remarks	Compiling the result in a Report, key findings

Figure 1: Research Methodology, Source: Author

Stakeholder Name	Contribution to the project by the Stakeholder							
	Administration	**Facility Receiver**	**Finance**	**O & M**	**Social**	**Implementing Agency**	**Academia**	**Monitoring**
Surat Municipal Corporation (Drainage Department)								
Surat Smart City Development Ltd.								
Gujarat Pollution Control Board								
Enviro Control PVT. Ltd.								
Pandesara Green Environment & Water Welfare Co-Op Society LTD. (PAGREW)								
South Gujarat Textile Processors Association. (SGTPA)								
SCET SVNIT								

Stakeholder Mapping

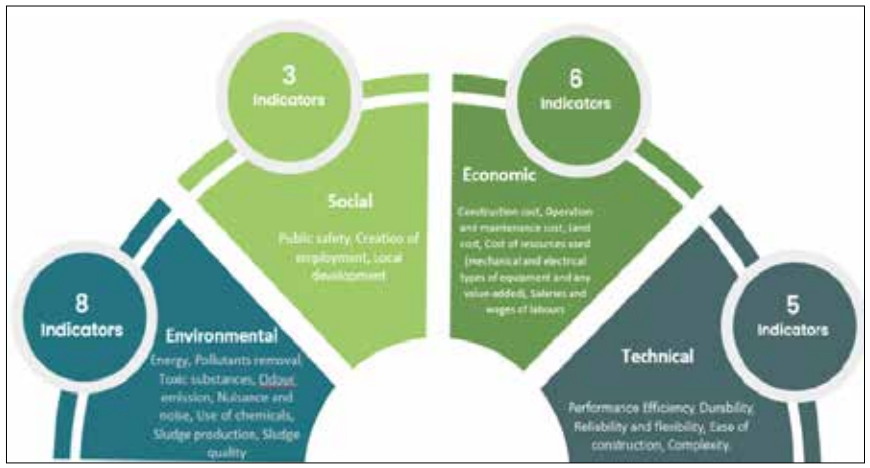


Figure 2: Dimensions and Indicators for Critical Evaluation
Source: Author

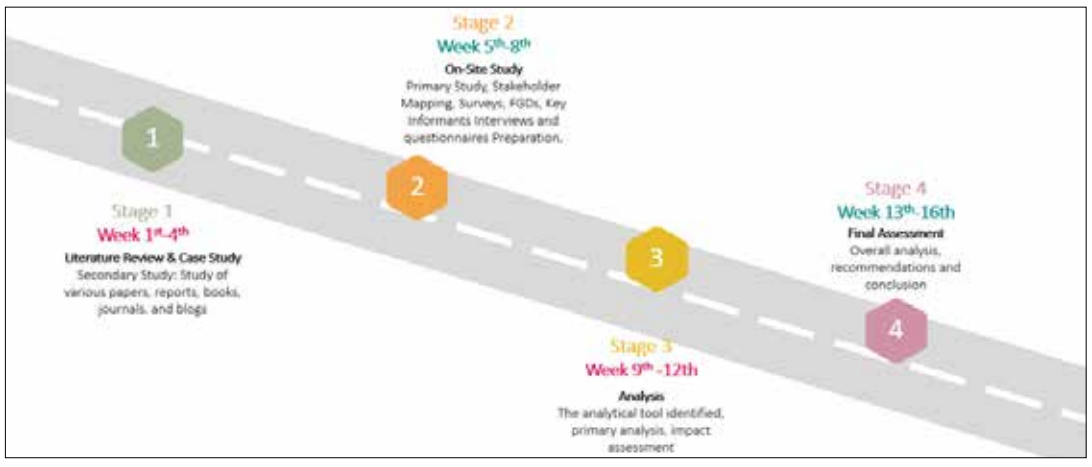


Figure 3: Stakeholder Mapping
Source: Author

identifying key informants from Surat Municipal Corporation (SMC), Surat Smart City Development Ltd (SSCDL), and other important institutions involved in the project, as well as conducting an interview-based perception study of the stakeholders. Secondary data was gathered through interactions and discussions with SMC, SSCDL, Pandesara Green Environment & Water Welfare Co-Op Society Ltd (PAGREW) and other stakeholders. A primary observation was also conducted on-site. Qualitative data, collecting data from interviews with key informants, focus group discussions (FGDs) and primary surveys are four categories of data obtained in primary and secondary surveys.

Following the completion of the literature review, case study, identification of various dimensions and indicators along with on-site study, all collected data was analysed (Stage 4) under the lens of identified dimensions and indicators for final assessment (Stage 5) to meet the research objectives.

2.2 Documentation of the project

The wastewater Tertiary Treatment Plant was proposed at the existing secondary site of the Sewage Treatment Plant site. Augmentation of the existing 66 MLD up to 167 MLD capacity STP up to a ten years period was initiated under another Smart City project along with the inception of wastewater TTP.

The primary goal of the tertiary sewage treatment is to produce, recycle and reuse industrial-grade water that may be used for industrial purposes without posing health risks or generating annoyance. The reject water treatment system is meant to deliver wastewater that meets the CPHEEO manual's, Ministry of Environment's and Gujarat Pollution Control Board's criteria for release into water bodies. Bhedwad Khadi is used to dispose the treated sewage. Total water requirement for Industrial-grade Water for Pandesara Industries is around 80 MLD. Bamroli TTP supplies around 40 MLD of tertiary processed water. As a result, an additional 40 MLD TTP was required to meet the remaining water demand. Annexure-3 shows the parameters of tertiary processed sewage/Industrial-grade water produced to meet the needs of Pandesara Industries.

The treatment plant is designed basis the following:

i. Final treated water quantity (Net output): 40 MLD
ii. UF Recovery attained/designed: ≥ 88%
iii. UF Flux LMH: ≤ 35 (Max)
iv. UF Membranes: Modified or reinforced PES to have good anti-fouling qualities.
v. RO Recovery attained/designed: ≥ 75%
vi. RO Flux LMH: ≤17 (Max)

Treatment of TTP is divided into three stages:

i. Pre-Treatment using fine filtration with Disk/Cloth Media
ii. Ultra-Filtration
iii. Reverse Osmosis (RO)

Following are the TTP's numerous components:

i. Civil Components

a. Filtration shed
b. Shed for entire UF/RO system with laboratory room
c. RCC UF/RO feed water tank with epoxy lining
d. Backwash/Reject collection tank
e. MCC room and transformer yard
f. f. Flash mixer, clariflocculator for UF/RO reject treatment with chemical dosing system
g. Foundations for all equipment/tanks/pump houses/degasser system

ii. Mechanical Components

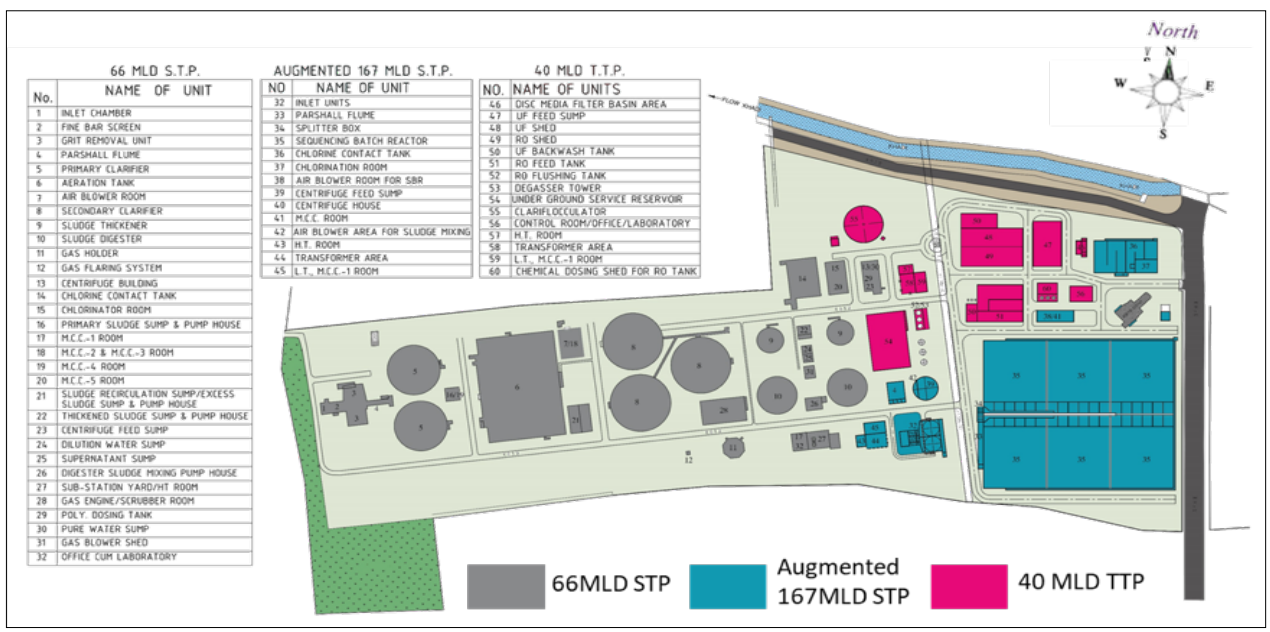
a. Disk/cloth media type fine filtration
b. Manual strainer (200-microns)
c. Ultra-filtration (UF) system comprising membrane modules and backwashing system
d. Cleaning in Place system (CIP) etc
e. Strainers/Filters in UF backwash line
f. UF backwash-cum-Reverse Osmosis (RO) feed tank
g. RO Feed pumps
h. De-chlorination facility to RO feed water
i. i.Cartridge filter for RO system
j. j.RO system with membrane modules, cleaning and flushing system
k. Chemical dosing system for RO operation and cleaning
l. Sludge De-watering unit for reject water
m. Degasser units|
n. ACF unit

iii. Electrical Components

a. HT panel
b. Transformers
c. MCC panels
d. APFC panel
e. PMC
f. Change over system to proposed TTP
g. MCC, HT and LT cables
h. Earthing systems
i. Push buttons
j. Plant and room lighting
k. Cable trays and tray supports, related civil work including cable trench etc

iv. Project Financial Structure

The project's financial structure was initially divided into three parts: Government of India, Government of Gujarat and Surat Municipal Corporation each accounting for 33 percent, 37 percent, and 30 percent of the overall project cost, respectively. However, during the project execution stage, the financial structure was



66 MLD S.T.P.

No.	NAME OF UNIT
1	INLET CHAMBER
2	FINE BAR SCREEN
3	GRIT REMOVAL UNIT
4	PARSHALL FLUME
5	PRIMARY CLARIFIER
6	AERATION TANK
7	AIR BLOWER ROOM
8	SECONDARY CLARIFIER
9	SLUDGE THICKENER
10	SLUDGE DIGESTER
11	GAS HOLDER
12	GAS FLARING SYSTEM
13	CENTRIFUGE BUILDING
14	CHLORINE CONTACT TANK
15	CHLORINATOR ROOM
16	PRIMARY SLUDGE SUMP & PUMP HOUSE
17	M.C.C.-1 ROOM
18	M.C.C.-2 & M.C.C.-3 ROOM
19	M.C.C.-4 ROOM
20	M.C.C.-5 ROOM
21	SLUDGE RECIRCULATION SUMP/EXCESS SLUDGE SUMP & PUMP HOUSE
22	THICKENED SLUDGE SUMP & PUMP HOUSE
23	CENTRIFUGE FEED SUMP
24	DILUTION WATER SUMP
25	SUPERNATANT SUMP
26	DIGESTER SLUDGE MIXING PUMP HOUSE
27	SUB-STATION YARD/HT ROOM
28	GAS ENGINE/SCRUBBER ROOM
29	POLY. DOSING TANK
30	PURE WATER SUMP
31	GAS BLOWER SHED
32	OFFICE CUM LABORATORY

AUGMENTED 167 MLD S.T.P.

NO	NAME OF UNIT
32	INLET UNITS
33	PARSHALL FLUME
34	SPLITTER BOX
35	SEQUENCING BATCH REACTOR
36	CHLORINE CONTACT TANK
37	CHLORINATION ROOM
38	AIR BLOWER ROOM FOR SBR
39	CENTRIFUGE FEED SUMP
40	CENTRIFUGE HOUSE
41	M.C.C. ROOM
42	AIR BLOWER AREA FOR SLUDGE MIXING
43	H.T. ROOM
44	TRANSFORMER AREA
45	L.T., M.C.C.-1 ROOM

40 MLD T.T.P.

NO.	NAME OF UNITS
46	DISC MEDIA FILTER BASIN AREA
47	UF FEED SUMP
48	UF SHED
49	RO SHED
50	UF BACKWASH TANK
51	RO FEED TANK
52	RO FLUSHING TANK
53	DEGASSER TOWER
54	UNDER GROUND SERVICE RESERVOIR
55	CLARIFLOCCULATOR
56	CONTROL ROOM/OFFICE/LABORATORY
57	H.T. ROOM
58	TRANSFORMER AREA
59	L.T., M.C.C.-1 ROOM
60	CHEMICAL DOSING SHED FOR RO TANK

Layout of Tertiary Treatment Plant

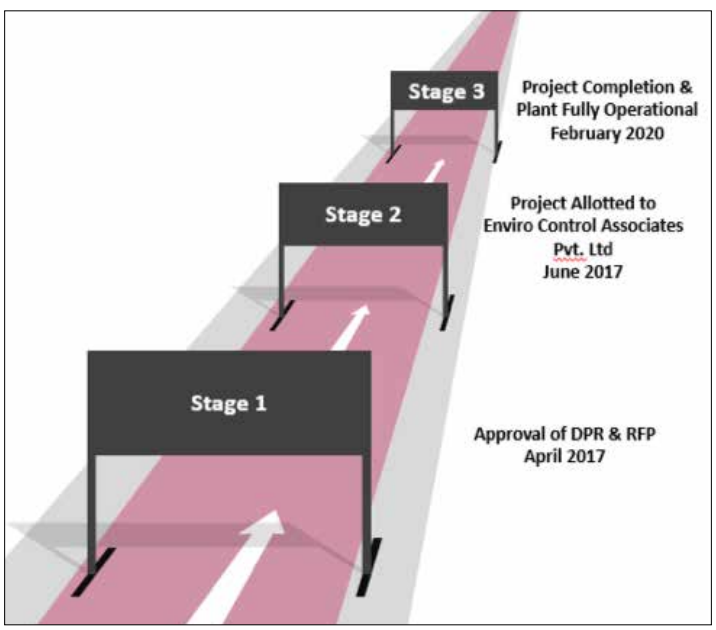


Figure 5: Project Phasing
Source: Author

altered and part of the total project cost was shared between Smart City Mission and Surat Municipal Corporation with 59.30 percent and 40.70 percent, respectively.

v. Project Management Structure

The project was completed in a professional manner by the SMC, who also issued an RFP for EPC contract for the project with favored bidders having a minimum turnover, financial strength and experience in executing similar sort and scope of works and so on. The contract was won by Enviro Control Associates Pvt Ltd, which had previously built the Bamroli TTP.

As the project was executed through the PPP model, areas of involvement of the private sector in the construction phase have been listed below:

a. Project feasibility study
b. Project engineering design
c. Specialised survey
d. Construction works
e. Supervision consultants
f. Quality assurance consultants
g. Material testing & inspection

2.3 Key features of the Project

2.3.1 Challenges in the Project

i. SMC faced significant challenges in terms of sewage quality and quantity, notably in ensuring that no industrial waste is mixed up with the sewage.
ii. The TTP requires a buffer tank to maintain a regular supply.
iii. An uninterrupted power source is required for the plant's continuous operation.
iv. After Tertiary Treatment, proper treatment of rejected water must also be arranged.
v. The secondary sewage treatment plant should be run in such a way that the secondary treated water's output parameters meet the TTP's permissible inflow characteristics.
vi. Because on-site components such as UF/RO are imported, staff training is essential. To avoid being reliant, internal capacity building should be performed.

2.3.2 Risks involved in the Project

Some of the risks in the Project include:

i. Environmental degradation
ii. Pollution
iii. Odour emission
iv. Nuisance & noise
v. Reduce Green cover

2.3.3 Features and Benefits

The major features of the project are UF/RO Technology and SCADA System.

UF/RO Technology:

Ultra-filtration (UF) is a membrane filtration in which two fluids separated by pressure or concentration gradients are separated by a semi-permeable membrane. The permeate contains water and low molecular weight solutes, while the retentate contains suspended particles and high molecular weight solutes. UF can be used to remove contaminants and macromolecules from water samples to produce drinkable water. It has been used to replace the existing secondary (coagulation, flocculation, sedimentation) and tertiary (sand filtration and chlorination) filtration systems in water-treatment plants, as well as standalone systems in remote locations with growing populations. When treating water with a high concentration of suspended particles, UF is usually employed as a pre-treatment stage in conjunction with primary (screening, flotation and filtration) and some secondary treatments. Some of the benefits of ultra-filtration over traditional treatment procedures are as follows:

i. Simple operation
ii. Low operating and maintenance cost
iii. Excellent operating environment
iv. High treatment efficiency
v. Strong sewage purification capacity
vi. Ease of construction
vii. Durable & flexible

Salient features of the SCADA System:

i. On the SCADA screen, a dynamic display of all units, equipment and drives is displayed.
ii. On the SCADA screen, all drives' run/trip indications are presented.
iii. PLC/SCADA has the capability of announcing and alarming. In the event of a fault, the equipment/drive symbol will continue to flash on the SCADA Screen, with the Equipment/Drive description showing at the bottom of the SCADA Screen, and the Electric Hooter will continue to sound until the Fault Alarm is acknowledged.
iv. SCADA allows data logging of each drive's running hours, alarms and historical trends on monitored parameters

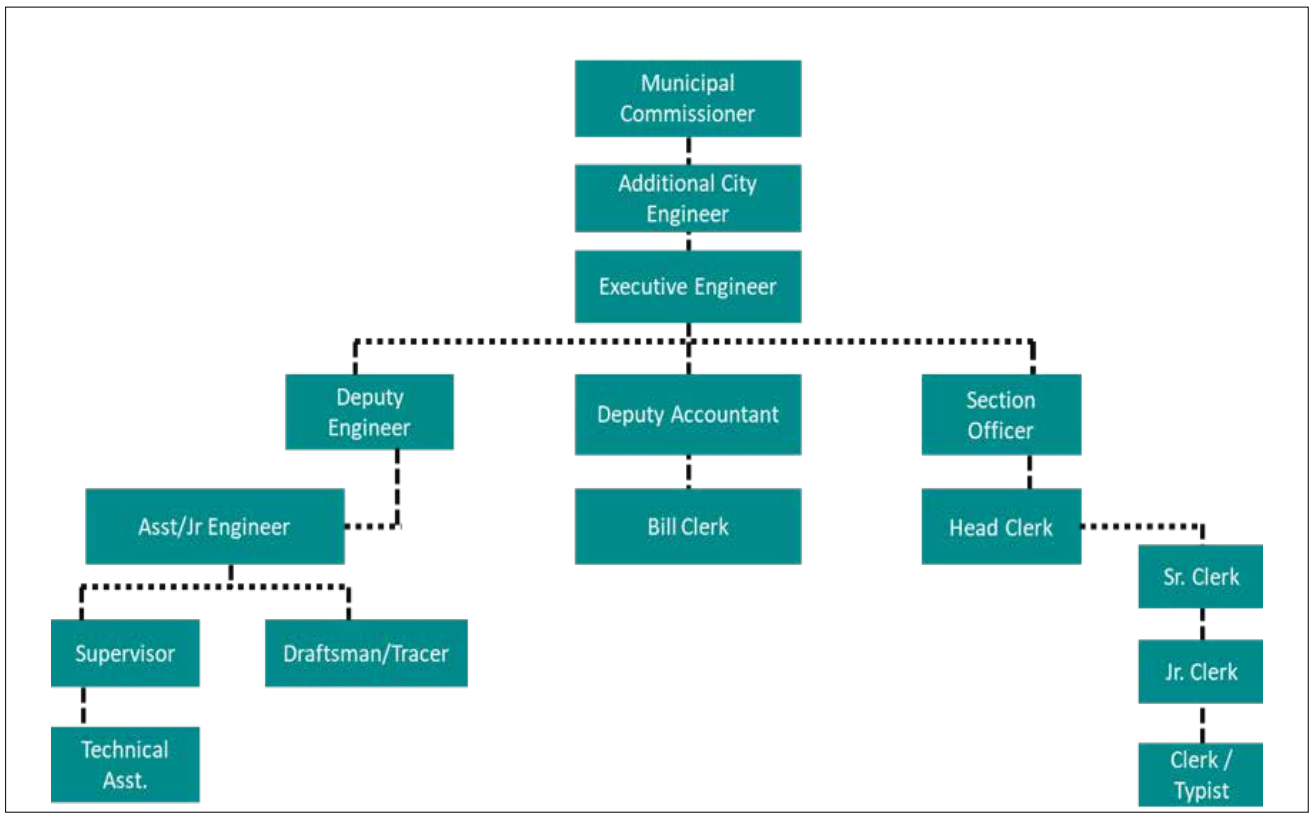
SCADA system improves worker safety, reliability and utilisation. Its warnings and real-time views of operations can help prevent minor issues from turning into major ones.

2.4 Key findings from interviews, surveys and primary/ secondary data collection

To understand the present scenario of the TTP a site visit was conducted along with focused group discussions and interviews with key personnel from various important stakeholders. Focus Group Discussion (FGD) was held with key persons from Surat Smart City Development Ltd (SSCDL) and Surat Municipal Corporation (SMC). To understand the impact of the wastewater TTP a primary survey was conducted within a 3.5-km radius of the plant. A total of 25 surveys have been conducted, of which 50 were household surveys and 75 industrial surveys. During the survey, key focus was on land distortion, odour emission, nuisance and noise and employment generation. Fulfillment of water demand and employment generation was the key focus of industrial survey. Findings from FGDs, key person interviews, surveys and primary/secondary data collection have been discussed below:

2.4.1. Environmental Findings of the Project:

a. Reduce load on the city's groundwater supplies for the benefit of the environment.



Institutional Structure

b. Reduce reliance on groundwater borings and private tanker operators for industrial units.

This ensures greater stability of water supply for industrial facilities by offering a secondary source of water as a supplement to drinking water as well as a reliable source for industrial units during times of scarcity. This tertiary treatment facility directly addresses "Water Stress," a major cause of concern around the world. As the project reduces reliance on private tanker operators it reduces the number of tanker trips to supply water. This has a direct impact on and reduces:
a. Fuel Consumption
b. GHG Emission
c. Air Pollution

The plant meets the treated wastewater standard parameters prescribed by CPCB and CPHEEO Manual 2012. The treatment plant's energy consumption is relatively high due to the use of UF/RO technology. It needs 27,000 kWh of energy each day, compared to 16000 kwh for the SLB benchmark.

2.4.2. Social Findings of the Project:
The TTP at Dindoli helps SMC to free up potable water that was supplied to the Pandesara industrial area which could be used to provide drinking water to citizens. This indirectly contributes to "Har Ghar Jal" scheme under "Jal Jeevan Mission" by the Government of India. The current trends in population growth and industrialisation have resulted in an increase in freshwater consumption. The supply of water sources is depleting as the demand for water increases. The gap between water availability and demand is widening every day. Dindoli TTP responds to the growing water supply-demand gap. As the Pandesara Industrial Estate receives 40 MLD water, Dindoli TTP is able to meet the water demand of Pandesara Industrial Estate and eventually eliminate the need to purchase water from the private sector at a significant cost. In Pandesara Industrial Estate, wastewater reuse has a cascade effect. The industrial estate will have sufficient resources to house Surat's leading textile factories. The treatment of wastewater and the elimination of contaminants also help to improve public health by reducing the risk of diseases spread by water.

Using Supervisory Control and Data Acquisition (SCADA) system helps to increase the safety of the workers. Dindoli TTP contributes 13% of the total wastewater reuse at the city level by SMC. It contributes directly to Surat becoming a water-plus city. Dindoli TTP also aids Surat's transition to a Climate Smart City by addressing indicator 3 of the Climate Smart City Assessment Framework (CSCAF) 2.0, which is wastewater recycling and reuse. Along with CSCAF 2.0, it also focuses on innovative engineering and technology interventions for water supply and quality, which is goal 3.4 of the Surat Resilience Strategy's pillar 3. The project generated employment opportunities for skilled labourers. The project also addressed the various SDGs and helped society to achieve a better and more sustainable future for all. Following is the list of SDGs along with the SDG targets which are addressed by the project:

i. SDG 6: Clean Water and Sanitation
Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimising the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally (The-Sustainable-Development-Goals-Report-2021, 2021)

ii. SDG 3: Good Health and Well Being
Target 3.3: By 2030, end the epidemics of AIDs, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases (The-Sustainable-Development-Goals-Report-2021, 2021)

Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination (The-Sustainable-Development-Goals-Report-2021, 2021).

iii. SDG 11: Sustainable Cities and Communities
Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to the global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor people in vulnerable situations (The-Sustainable-Development-Goals-Report-2021, 2021).

iv. SDG 13: Climate Action
Target 13.1: To strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries (The-Sustainable-Development-Goals-Report-2021, 2021).

Also, no land distortion happened as the tertiary treatment plant was built on the existing sewage treatment plant site.

2.4.3. Financial Findings of the project:
By treating the wastewater and supplying it for industrial reuse the treatment plant is contributing to circular economy. No land costs were necessary because the TTP was built on the site of an existing sewage treatment plant. The project's total capital cost is Rs 125 crore out of which SMC will bear Rs 50 crore. The annual cost of operation and maintenance is Rs 27.6 crore. SMC charges Rs 31.82/Kl for supplying industrial quality water to Pandesara Industrial Estate, which is affordable and substantially less than private tanker operators. The SMC is generating Rs 45.82 crore per year by supplying industrial-grade water from Dindoli to Pandesara Industrial Estate. It is apparent that SMC is recovering its operating and maintenance costs and have a surplus of Rs 18.22 crore. This treatment plant uses UF/RO technology which has a high capital cost initially as it must be imported but has a low maintenance cost. The use of the Supervisory Control and Data Acquisition (SCADA) system also helps to reduce maintenance cost. As there is no facility for sludge recycling no revenue can be generated from it.

2.4.4. Technical Findings of the Project:
The wastewater TTP at Dindoli uses latest technology like UF/RO to treat secondary treated water. Advantages of this technology are:
i. Simple operation
ii. Low operating and maintenance cost
iii. Excellent operating environment
iv. High treatment efficiency
v. Strong sewage purification capacity
vi. Ease of construction
vii. Durable & Flexible

The only disadvantage of this technology is that it requires more power/energy than other technologies. Also, the use of Supervisory Control and Data Acquisition (SCADA) system provides improved worker safety, reliability and utilisation. Its warnings and real-time views regarding operations can help prevent minor issues from turning into major ones.

3. Discussion and Conclusion

3.1 Implications
Currently, 308 MLD water is being reused by Surat after necessary treatment. The TTP at Dindoli contributes 13% of the total treated reused water to the city. Surat's transformation into a Water Plus City is being boosted by this project, which is also contributing towards Surat becoming a Climate Smart and Resilient City. In the long run, the TTP at Dindoli will reduce the diversion of drinking water for non-potable purposes. It will also reduce the dependence of Pandesara Industrial Units on unauthorised bore-wells and private tanker operators. The project also facilitates the recycling of wastewater, an environmentally sound and progressive practice. It protects the current revenues of SMC from the sale of water for industrial purposes and involves no investment or O&M cost to Surat Municipal Corporation. It offers an opportunity to the private sector to contribute to investing in the infrastructure sector within a regulated framework. Following are the key implications of the project:

i. Water Plus City:
The tertiary treatment plant project at Dindoli contributes directly towards making Surat a Water Plus City by generating 12% treated wastewater for reuse.

ii. Climate Smart City:
The tertiary treatment plant is helping Surat become a Climate Smart City through wastewater recycling and reuse.

iii. Value Addition to SDGs:
The project is addressing various SDGs and helps

society to achieve a better and more sustainable future for all. This project addresses SDG 3.3, 3.9, 6.3, 11.5 and 13.1.

iv. Circular Economy:
By treating wastewater and supplying industrial-grade water to Pandesara Industrial Estate (Waste to resource) Dindoli TTP is directly contributing to circular economy.

v. Water Preservation:
The project is helping Surat Municipal Corporation to reduce the city's reliance on groundwater resources for the benefit of the environment. It also ensures valuable groundwater resources are preserved for future generations.

vi. Revenue Generation:
The project is generating guaranteed revenue for Surat Municipal Corporation by selling treated wastewater to Pandesara Industrial Estate.

vii. Smart Solution:
Control via SCADA system improves the accuracy and reduces equipment maintenance.

3.2 Limitations of the Research

To critically review the project, rigorous research and detailed methodology were followed. However, the study faced certain limitations:

The project's distinctiveness is the limiting factor. The study's findings are largely applicable to the development of similar tertiary treatment plants. Other limitations could include insufficient or incomplete data.

3.3 Key Lessons Learnt

The following are some important lessons learned through the implementation of this project:

i. Maintaining the quality and quantity of sewage arriving at the STP with little change and fluctuation.
ii. Maintaining the necessary flow between secondary and tertiary treatment outlets.
iii. Uninterrupted power supply to the plant to permit continuous operation.
iv. No illegal discharge of industrial waste into the sewage system and any problems discovered to be remedied immediately.
v. A buffer tank is required to ensure continuous supply to the tertiary treatment facility.
vi. The secondary sewage treatment plant should be operated so the water's exit parameters meet the tertiary treatment plant's permitted inflow characteristics and its operation and maintenance should be assigned to a single agency.
vii. To build internal capability for sustaining on-site components such as UF/RO which are imported.

3.4 Recommendations

i. Recycle & Reuse of Sludge:
After a thorough analysis of the wastewater TTP, it is observed that the sludge produced after treatment is disposed at the Khajod landfill site which is 13-km away and the sludge is not being reused. During transportation from the treatment plant to a landfill site the sludge is contributing to GHG emissions and air pollution. Instead of transferring the sludge to a far landfill site the produced sludge can be processed at the existing site for recycling and reuse through Biochar Technology. Bricks can also be made from the sludge discharged after treatment. Recycle and reuse of sludge will address Sustainable Development Goal (SDG) 7 which is Affordable and Clean Energy.

ii. Energy Production:
Methane is generated during the treatment process which should be trapped and used after quantification for fuel industries.

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Annexure 1: Details of STPs along with Designed and Utilizing Capacity

S.No	Location	Year of commissioning	Capacity (MLD)		Process
			Design	Utilizing	
1	Anjana	1995/2007	122	85	Conventional Activated Sludge
2	Bhesan	1995/2009	100	95	Conventional ActivatedSludge
3	Bhatar	1999/2014	162	140	Conventional Activated Sludge/SBR
4	Karanj	1999/2015	140	130	Conventional Activated Sludge/IFAS
5	Singanpore	2003/2014	155	150	Conventional Activated Sludge/SBR
6	Bamroli	2008	100	95	UASB + Extended Aeration
7	Asarma	2011	15	10	Moving Bed Bio Reactor
8	Khajod	2011	25	20	Moving Bed Bio Reactor
9	Variav-Kosad	2012	134	110	UASB + Moving Bed Bio Reactor
10	Dindoli	2012	66	40	Conventional Activated Sludge
11	Gavier	2016	53	5	SBR
	Grand Total		1072	880	

Annexure 2: Parameters of tertiary processed sewage

Sr. No.	Parameter	Unit	Raw Sewage (90%tile)	Secondary treated sewage	Tertiary Treated – Industrial Grade Water
1	2	3	4	6	8
1	True Colour (Hazen Units) max.	Hazen Units	90	50	< 5
2	Turbidity	NTU	*	*	< 5
3	pH	-	6.5 – 7.5	7 – 8.5	6.0 – 7.5
4	Total Hardness as CaCO3	mg/l	900	*	< 300
5	Iron as Fe	mg/l	0.72	*	< 0.25
6	Manganese as Mn.	mg/l	0.4	*	< 0.10
7	TDS	mg/l	1400	1400	< 500
8	BOD5	mg/l	250	≤ 10	< 5
9	COD	mg/l	600	≤ 50	< 50
10	Total Suspended Solids	mg/l	300	≤ 10	< 2
11	Total Nitrogen as N	mg/l	42	≤ 10	< 10
12	Total phosphorus	mg/l	7	≤ 2 (as dissolved -P)	< 7

Annexure 3: Operation and Maintenance Cost

STAFF	Nos.	Salary/month	Total Salary
Plant in charge	1	30000	30000.00
Instrument Engr.	4	30000	120000.00
Supervisor	3	20000	60000.00
Chemist	3	15000	45000.00
Fitter/Plant Operator	7	9500	66500.00
Elect. Technician	7	9500	66500.00
Operators/Beldar	14	6500	91000.00
Security	9	7000	63000.00
Supervisor - Security	1	15000	15000.00
Gardener	1	6500	6500.00
			563500.00
	PF	13.61%	76692.35
		5%	32009.62
	ESI	6%	33810.00
		Total	706011.97
	Service Tax	15.00%	105901.80
		Total Salary Expense per Month	811913.76
		Total Salary Expense per Year	9742965.15

Total Cost per year	276984377.11
Total Cost per ML	18971.53
Total Cost per KL	18.97

			Amount per year	Service Tax	Total Cost peryear
Membrane Replacement	1300000	Rs. / ML / year	52000000.00	52000000.00	52000000.00
Spares Replacement (0.5% of Capex)			5881401.70	882210.26	6763611.96
Variable Cost	1850	Rs. / MLD	26640000.00	3996000.00	30636000.00
Electricity Cost (Rs. 6/- perKWH)	4050	Rs. / MLD	58320000.00		58320000.00

			Amount per year	Service Tax	Total Cost peryear
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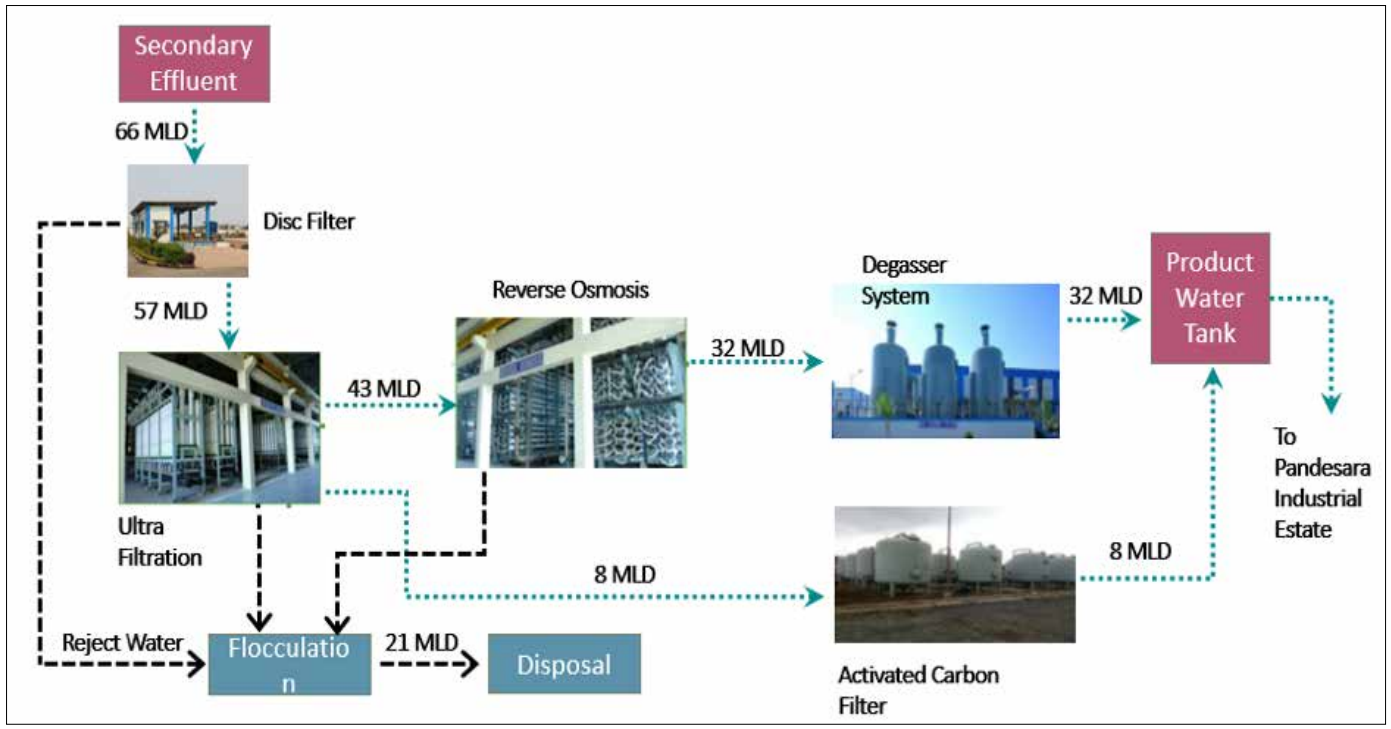
Electricity Cost (Rs. 6/- perKWH)	4050	Rs. / MLD	58320000.00		58320000.00

Annexure 4: Site Photographs



B3

Restoration of Waterbodies – Coimbatore

Name of the project: *Restoration of Eight Water Bodies*
Location: *Coimbatore, Tamil Nadu*
Year of project implementation: *2015*
Sector: *Water Secure Cities*
Project Cost (Rs. 349.47Crore)
Linkages to SDGs:
SDG 3, SDG 6, SDG 8, SDG 11, SDG 13, SDG 14, SDG 15, SDG 17

Institute: *Dept. of Planning, Anna University*
Advisors: *Dr.K.Pratheep Moses, Mr.P.Sudharsanamurthy, Ms.K.Madhivadhani*
Students: *Subashri S K, Shree Niveditha K*

Keywords: *Lake Restoration, Environmental Benefits, Biodiversity, Ecosystem, Smart City Mission*

Abstract:

Lakes and their shoreline not only offer a plethora of environmental benefits, but also positively influence the quality of life of the inhabitants around them, besides strengthening the economy. Lakes play a vital role in water management, by holding large volumes of water or releasing it, during droughts and floods. Lakes also enable groundwater recharge, improve the water quality of downstream watercourses, and protect the area's biodiversity and ecosystem. Lakes provide us with excellent recreational, tourism, and cottage or residential dwelling opportunities. Lakes can also serve as a source of water for industry and irrigation for agriculture. Therefore, one can say that it is an essential natural resource that we stand to reap profits from.

On the other hand, a lake, can't fully fulfil its role if it's left unmanaged and poorly managed, and it can even be dangerous to the environment. As a result, when it comes to lake management, lake restoration is quite important. The Report discusses and reviews the Lake Restoration Project carried out by Coimbatore Corporation which is the most active among the State's 11 urban local bodies in implementing projects supported by the Central Government's Smart Cities Mission.

Coimbatore is located in the Noyyal basin and has an extensive lake system (built by Cholas 1200 years back) fed by the river and rainwater runoff. Narsampathy, Krishnampathy, Selvampathy, Kumaraswamy, Selvachintamani, Periyakulam, Valankulam, Singanallur tanks are the eight (out of how many?) largest tank areas of Coimbatore.

The paper critically analyses the Project in terms of its Methodology, strategies and Implementation, which focuses on the rejuvenation of its lakes as part of the Smart City goal. It assesses its policy in terms of regulations regarding removal of encroachments, and restoring and developing the lakefronts as curated public open spaces along the lakefronts. The goal of the project is to re-establish the city's lost link with its natural assets.

Case Study: B3

1. Introduction

Coimbatore is called as the Manchester of South India and is located in Tamil Nadu. The Noyyal River, which flows through Coimbatore and forms the city's southern boundary, is separated into five sections: north, south, east, west, and centre. The town is located in the Noyyal basin and has a large lake system that is supplied by the river and rainwater runoff. The eight major tank sites in Coimbatore are Narsampathy, Krishnampathy, Selvampathy, Kumaraswamy, Selvachintamani, Periyakulam, Valankulam, and Singanallur. The project covers the restoration of these eight lakes.

1.1 Topic and context

Lakes and wetlands are not governed by any special legal statute, however several legislations enacted till date have relevance & provisions for conservation of lakes. Some of them are, The Water (Prevention & Control of Pollution) Act' 1974 as amended deals comprehensively with water issues. The Environment (Protection) Act' 1986 defines the power of the Central Government to take measures to protect and improve environment. The National Environment Policy' (NEP), 2006, recognises the ecological services rendered by the water bodies like lakes & wetlands.

The Smart cities mission of the Government of India was launched in the year 2015, and Coimbatore city Municipal Corporation was selected through a competitive process. Coimbatore City's Smart City Plan focuses on revitalising the eight-lake network by launching a project to develop an Eco-restoration Master plan of eight lakes and a connecting greenway, with the goal of revitalising environmentally sensitive areas and introducing sustainable and enhanced public spaces around the lakefronts. The Project areas and their extents are elaborated in Table 1.

1.2 Significance of the project

- Periyakulam is the city's largest and most centrally placed lake due to its size and position. The lake is easily accessed by many people, including those who do not live near the lake, due to its proximity to the city's commercial centre and the position of significant transit hubs. The lake might potentially become a popular tourism destination for the city. Vendors, hawkers, food kiosks, and other businesses have been established to help the lakeside promenade become a bustling, activity-filled spot in the city. This would not only boost the livability quotient of the city but also function as a thriving public open space.
- Selvachintamani is surrounded on all sides by residential zones, and this new lakefront promenade would serve both locals and tourists alike. Accordingly, the design elements focus on establishing people-friendly spaces, including a variety of play areas for children of various ages, areas for visitors to sit and enjoy the view of the lake, and plazas. The restoration project also includes public conveniences, street furniture, plaza lighting, signs, planting, and plaza paving.
- Valankulam lake is in close proximity to major social infrastructures and thus can be accessed by many people. The lake's size and position make it a popular tourist attraction in the city. The lakefront design includes a cycling network, a promenade, and other urban design components.
- Kumaraswamy also receives water for the River Noyyal's northern watershed. Slum encroachments can be seen on the eastern and northern edges of Kumaraswamy, which are being repaired by the city authorities. Once all of the encroached property is freed up, it is proposed that all of the newly available land be used for water treatment and placemaking operations.
- The wetland centre of Tamil Nadu University of agriculture and technology is located on the southern side of Krishnampathy Lake. The majority of the water in the lake is sewage water. Encroachments along the lakes are currently intended to be eliminated, to make way for developing new vibrant public spaces where people may interact with the lake and its surroundings.
- Singanallur Lake is surrounded by agricultural fields on 3 sides. This lake is vertically divided by a railway track. The northern part consists of a defunct boat house and urban area, the southern part remains isolated as it does not have any direct access to an of the arterial roads. This lake is home to various species of flora and fauna. , thus the proposal concentrated on the "green infrastructure" all around the lake.
- Narsampathy Lake is home to a variety of bird species. The proposed interventions are intended to improve the lake's ecology and restore water flow.
- As seen in Figure 1, this Lake Restoration project is in close sync with the Sustainable Development Goals (SDG) set up by the United Nations in 2015.

1.3 Aim and Objective:

The aim of the study is to understand the implementation mechanism and strategies adopted by the lake restoration project and to analyze its impact on Coimbatore city.

The objectives of the study are:

Figure 1 – Linkages to SDGs
Source: Author

Sl. No	Project Area	Project Extent
1	Restoration and Rejuvenation of Periyakulam Lake	Total perimeter 4.0 km. average width 6m-10m
2	Restoration and Rejuvenation of Selvachintamani Lake	Total perimeter 1.5 km. average width 4m-7.5m
3	Lake Rejuvenation and Restoration Valankulam	Total perimeter 6.5 km. average width 5m-7m
4	Lake Rejuvenation and Restoration Selvampathy & Kumaraswamy	Total perimeter 5.3 km. average width 4m-7.5m
5	Lake Rejuvenation and Restoration - Krishnampathy	Total perimeter 2.6 km. average width 4m-7.5m
6	Lake Rejuvenation and Restoration - Singanallur	Total perimeter 4.0 km.
7	Lake Rejuvenation and Restoration Narsampathy	Total perimeter 3.8 km. average width 6m-10m

Table 1- Project details Table 1- Project details
Source: Detailed Project Report

a. To understand the selection criteria adopted for this project
b. To analyse the project designing process, its implementation and maintenance strategies.
c. To understand the impact of the project on the economy of Coimbatore city
d. To analyse the role of stakeholders in the implementation of the project
e. To learn about the key findings and scope of replicability of the project

2. Contextual Background

Blue assets such as Lakes are vital resources for the sustenance of life above land and below water alike. Lakes have mild temperatures and have an impact on the ecology around them. By storing water, water flow can be controlled; groundwater aquifers can be rejuvenated, and frequency of droughts can be reduced. Lakes provide a thriving habitat for aquatic and semi-aquatic flora and fauna, which in turn are part of a larger food chain.

Table 2 – Location of the lakes

S. No	Name of the lakes	Geographic location
1	Periyakulam	N 10°58' 44" E 76°56' 43.56"
2	Selvachintamani	N 10°59' 24.29" E 76°56' 48.91"
3	Krishnampathy	N 11°00' 21.05" E 76°55' 28.90"
4	Kumaraswamy	N 10°59' 27" E 76°56' 42"
5	Selvampathy	N 10°59' 27" E 76°56' 42"
6	Valankulam	N 10°59' 48.41" E 76°59' 3.39"
7	Singanallur	N 10°59' 50.34" E 7°01' 15.68"
8	Narsampathy	N 10°59' 58" E 76°54' 31"

Source: Detailed Project Report

Coimbatore District located in Tamil Nadu is known as the "Manchester of South India." The river Noyyal flows into the district originating from Velligiri hills of Western Ghats and is a tributary of river Cauvery. The Noyyal River, which flows through Coimbatore and forms the city's southern boundary, is separated into five sections: north, south, east, west, and centre. The town is located in the Noyyal basin and has a large lake system that is supplied by the river and rainwater runoff. The eight major tank sites in Coimbatore are Narsampathy, Krishnampathy, Selvampathy, Kumaraswamy, Selvachintamani, Periyakulam, Valankulam, and Singanallur. The location details of the project are given in Figure 2 and Table 2.

The concept of lake restoration under the Smart City Plan is a historic opportunity for Coimbatore to improve water security and become more climate-resilient while also increasing the quality of its public realm for both its residents and the tourists. As a result, the project addresses the City's requirement for an overarching plan to lead a phased development approach for lake eco-restoration. Thus, giving a concrete form to Coimbatore's long-term vision to become more sustainable and self-reliant.

Periyakulam Lake

Periyakulam Lake is geographically located to the south of Coimbatore, west of the city's major railway line, and north of the Noyyal River. Periyakulam lake's storage capacity was estimated to be 19, 80,763 cum (69.95 Mcft) based on a combined catchment area of 52.32 sq. km and a contributory catchment area of 10.88 sq. km.Besides, the watershed catchment area, a separate agreement was created to supply water from the Noyyal River via the Coimbatore Anicut Canal. The restoration of Periyakulam lake before and after pictures are shown in Figure 3.

Valankulam Lake

The Valankulam Lake is located on Coimbatore's southern outskirts and is within Coimbatore's corporation limit. The lake's main bund stretches from the lake's northernmost point to its southernmost point along the Sungam Ukkadam by-pass route.

Selvachintamani Lake

Selvachintamani Lake is the smallest of the Phase-I lakes and is located within Coimbatore's core corporate limits. It is surrounded by a completely built-up catchment region with developed areas with minimal vegetative cover and open ground. The lake's main bund is connected to Perur's major road. Selvachintamani was designed to hold 3.02 million cubic feet (85,517 cubic meters) of storage in a catchment area of 1.69 square kilometres. The restoration of Selvachintamani lake before and after pictures are shown in Figure 4.

Kumaraswamy Lake

Kumaraswamy Lake is the fourth and last Phase-III lake with a completely build up catchment area and the lake's north bund is connected to Thondamuthur road from the lake's north eastern to north western portions. This lake is connected to Krishnampathy in the upstream with a surface area of 71.7 acres.

The majority of the Selvampathy catchment region is under the control of the Tamil Nadu Agriculture University (TNAU), which is primarily open fields with a section of the catchment consisting of residential built-up areas with developed urbanised packages. The Selvampathy Lake is located within the Coimbatore city

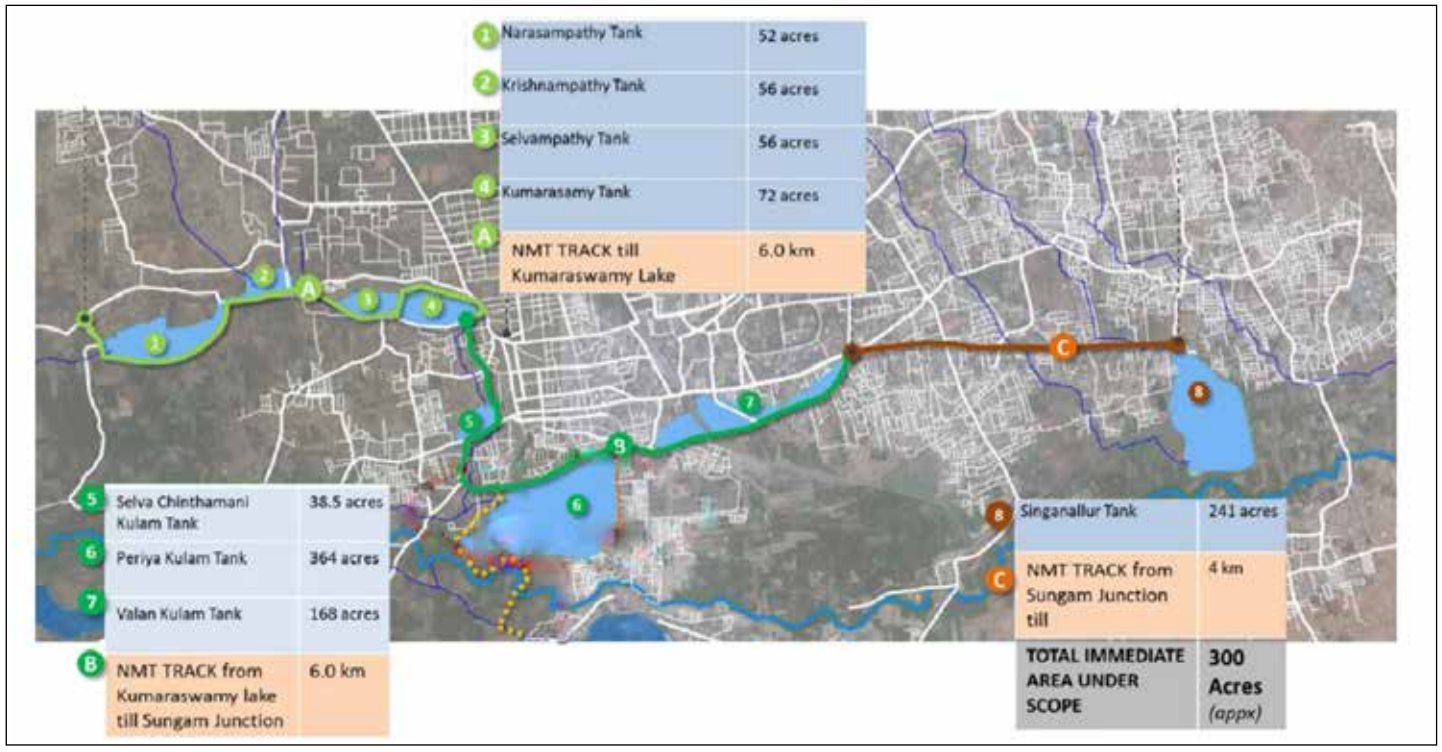


Figure 2 – Location of lakes
Source: Detailed Project Report

Figure 3 - Periyakulam Lake - Western Bund
Source: Author

corporate borders, and the lake's main bund stretches from the north-western corner to the south eastern corner. All the 8 lakes are inter-connected with each other and eventually joins the Noyyal River on the city's outskirts.

2.1 Conceptual framework / Research design

The methodology focuses on a review of the Project's Implementation by analysing the transformation from the before and after pictures of the Restoration work implementation, i.e., what caused the change and how it has impacted the city. The analysis will also look into the functioning of the system, operational features, as well as implementation strategies, and the particular actions that would be conducted in accordance with the adopted strategy and plan, which would be crucial in driving change. The above study is based on Stakeholders and Sustainability, and it takes into account a variety of aspects such as technical, financial, sustainable, environmental, social, and legal factors. This analysis serves as the foundation for the subsequent assessment.

Beneficiary assessment entails conducting systematic consultations with project beneficiaries and other stakeholders to assist them in identifying and designing development activities, identifying any potential barriers to their participation, and obtaining feedback on how an intervention is being received during implementation. The economic rationale for any proposed investment is determined by weighing the expected benefits of the investment against the overall costs required to complete the activity successfully. The replicability is determined by determining whether the model implemented is repeatable - in other words, what are the criteria for replicating the model in any city. The important learnings from the study in terms of inclusivity, strategy, plan, and implementation model of Smart City Plan for Coimbatore, focuses on revitalizing the eight-lake network by launching a project to develop an Eco-restoration Master Plan for eight lakes and a connecting greenway, with the goal of redeveloping environmentally sensitive areas and introducing sustainable and improved public realm around the lake edges. Figure 5 elaborates the research framework for the study.

2.2 Key features of the project

i. Revitalize the lakes and surrounding area of approximately 1000 acres into active and vibrant neighbourhoods with recreational facilities that are environmentally sustainable.
ii. Improve access to the lakes from the surrounding neighbourhoods by providing safe and convenient mobility corridors for all users including pedestrians and cyclists.
iii. Protect and enhance biodiversity in the region
iv. Explore possibilities for developing tourism in the region with improved scope for commercial development in the project area
v. Appropriate design and management of drainage basin
vi. Maximize the holding capacity of a lake
vii. Divert wastewater flow, away from the lake
viii. Treat wastewater entering the lake for healthy ecological systems

2.2.1 Challenges in the project

i. The drain is clogged with trash and solid waste at the lake's entry point and down the drain. Currently, small volumes of residential sewage inflow, sediment transport, and rubbish accumulation find their way into the lake's drainage basin.
ii. Most of the lake's catchment area is completely built-up, with pockets of developed land, vegetative cover, and open ground.
iii. The inlet entry point of the lake was choked with froth formation is observed at the entry portion of the lake due to the wastewater inflow and afflux. The existing structure is found to be damaged (Krishnampathy existing weir).
iv. The drains are choked with collection of debris and solid waste. Construction debris has been dumped along its bank of the drain reducing its carrying capacity
v. The sluice has been artificially blocked with a stone slab to stop the passage of water through it. The

Figure 4 - Selvachintamani Lake - Southern Bund
Source: Author (clicked on ?)

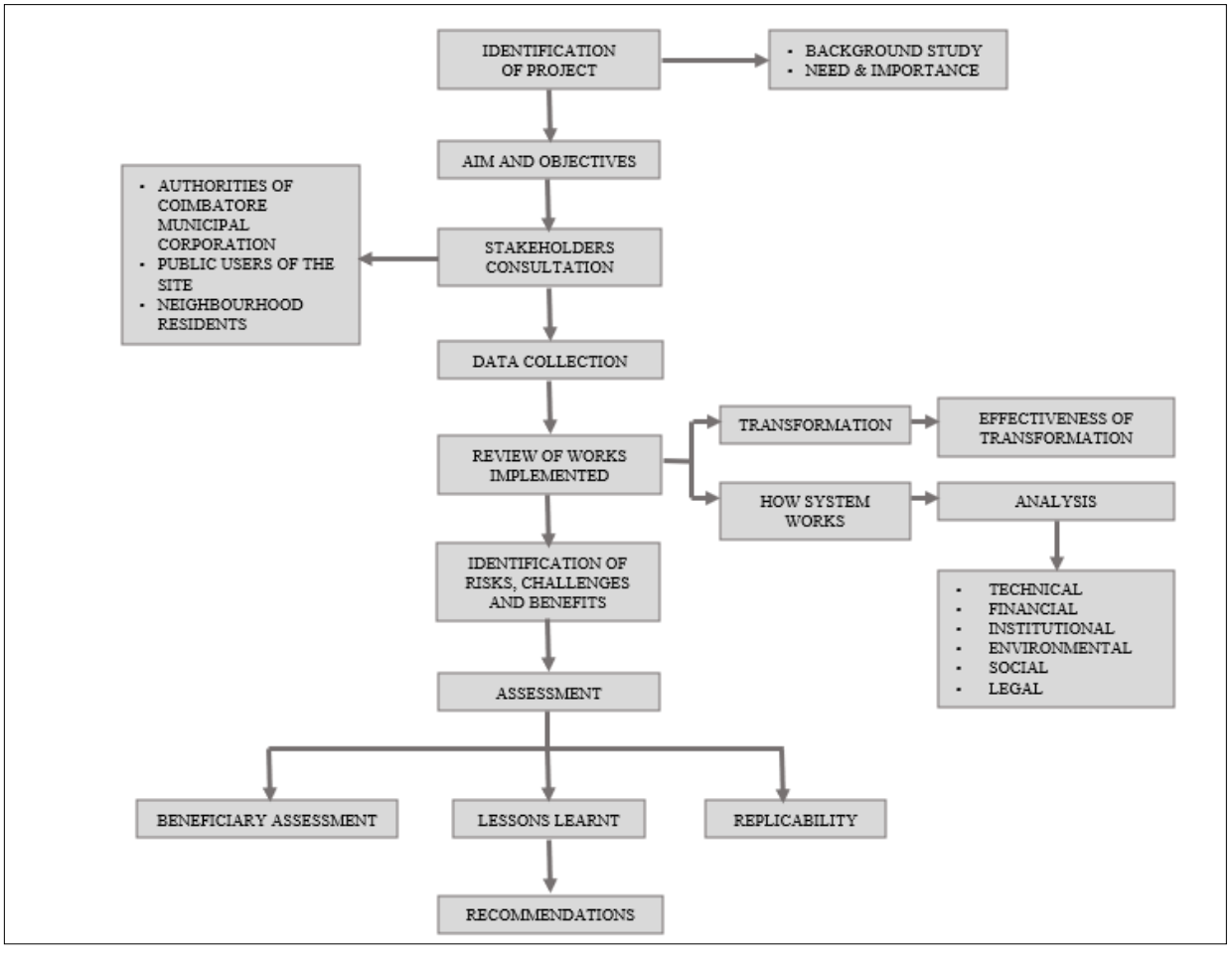


Figure 5 – Research framework
Source: Author

height of the sluice on the lake side with the outlet on the downstream side was found to be insufficient for water discharge to the downstream.

vi. The natural drainage pattern of the contributing catchment area has been disrupted as a result of rampant urbanization, resulting in a portion of the catchment area not contributing to the inflow into the lakes.

vii. Several drains are connected to the lake and contribute to its degradation.

viii. Debris dumping (plastic garbage) has been recorded all along the lake's periphery.

2.2.2 Risks involved in the project

i. The dry weather flow drains contribute to the influx of household sewage into the lake.

ii. The land use pattern in this catchment area is currently classified as completely built-up, with mixed residential layouts/complexes, high-rise apartments, commercial complexes.

iii. The slum growth near the lake area directly contributes to the waste water flow, as well as dry weather flow from the urbanised areas of the Catchment area.

iv. Inlets have been obstructed by the dumping of solid wastes/debris, yet there is a limited flow of waste water into the lake. A portion of the lake's body is used as a dumping yard.

v. The headwall, wing wall, apron, and protection wall of the weir are in poor condition. The surplus arrangement's discharge carrying capacity does not appear to be sufficient to handle the predicted flood discharge as shown in figure 6.

2.2.3 Benefits of the Lake restoration project

i. Formulation of an Integrated plan to comprehensively enhance the existing connection of the city with its 8 lakes. The 32 KM cycle track connecting all the restored lakes connects major landmarks of the city which would enhance the non-motorized transport connectivity.

ii. In addition, the lakes would be surrounded by inclusive public spaces, parks, open zoological parks, and botanical gardens.

iii. Enhanced water quality monitoring of the lakes.

iv. Extensive studies would be conducted of the biodiversity around the lakes.

v. Exclusive walkways will be built to encourage walking, jogging, and cycling, with skywalks being built across the roadways.

vi. Disability ramps, seating arrangements, bike parking, footpath, sign symbol, cycling lane footpath, drinking water, lighting, passengers shed, and bus bays would form a part of the social infrastructure around these lakes.

vii. Efficient CCTV surveillance to assist the existing traffic network.

2.3 Key findings from the interviews, surveys, and primary/secondary data collection

Interviews and surveys were conducted on-site with stakeholders who are directly affected due to this project. The survey questionnaire is attached as Annexure 1. Based on the discussions, following are the key findings about the restoration project.

i. The unauthorized development along the lakes has been removed and the lake boundary is defined by pavements and other structures. This will protect the lake area from future encroachments.

ii. The local people living in the neighbourhood area near the lake are benefiting highly with the enhanced green cover and newly created walkways.

iii. The ambience of the area is completely changed. Initially there was extensive garbage dumping and unmaintained waterbodies, but now, the lakefront areas are transformed.

iv. The inlets and outlets of the lakes were cleaned and restored. This enhanced the water flow from one lake to another. This helps in preventing flooding and maintaining a healthy water level across the lakes.

v. Introduction of steps such as proper timings for accessing the lakes, deployment of security guards and CCTV monitoring makes the space more secure. The crime rate has reduced near the lake as initially they were abandoned, isolated spaces but now, they have been transformed into highly accessible and efficiently used public spaces.

vi. The quality of the water in the lakes has improved drastically. They are cleaned periodically and maintenance is done on daily and monthly basis.

3. CONCLUSIONS

3.1 Implications

As a result of this rejuvenation project, the growth of aquatic species has improved. Water contamination has also reduced due to the water treatment done in the inlets of the lakes. Pollution free water in the surrounding area is critical for aquatic life.

The restored lakes are constantly monitored through

Figure 6 – Damaged wall
Source: Author

CCTV. Timings for accessing the lakes also helps in controlling the exploitation of the public resource. The crime rate is also reduced in the vicinity of these lakes due to conversion of the abandoned spaces into highly inclusive and interactive spaces, thereby, transforming Coimbatore city's identity.

3.2 Limitations of the research

The study focuses on a review of project implementation by assessing the transformation between the before and after phases of implementation. The study focuses on the implementation strategies, operational features and strategy plans which were crucial in driving the change. The study is based on stakeholders and takes into account the technical, financial, environmental and social aspects.

3.3 Key lessons learnt

i. Removing unauthorised establishment would give space for new improved amenities.
ii. Defining and protecting the boundaries of the lake protects the lake area from getting encroached.
iii. Treatment of waste water and inlet source helps in reduction of lake contamination.
iv. Proposals such as food courts, water sports, light and sound show, boating, etc. would help in improving the economic viability of a lake restoration project.

3.4 Recommendations

i. Proposal for entry tickets would make the general public more responsible towards using the public resources.
ii. Provision for food courts, kiosks, small shops supporting traditional craftsmen which would not only help in investing in maintaining the lake and its surroundings, but also recognize and help local craftsmen.
iii. Provision for biogas plants within the lake, using the waste from public restrooms. This would also help light up the lake premises and the use of solar panels in the roof of food courts and kiosk shops would help in using renewable source of energy making the project sustainable in the long run.

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QUESTIONNAIRE FOR ON-SITE SURVEY

Smart Cities and Academia towards Action & Research Program (SAAR)

Project Name - Restoration of Water bodies in Coimbatore Smart City

Location –
Date -

PUBLIC PERSPECTIVE ABOUT THIS PROJECT

Q1. Is this project useful to your locality?
இந்தத் திட்டம் உங்கள் பகுதிக்கு பயனுள்ளதா? YES / ஆம் NO / இல்லை

Q2. Have your flaws been solved by this project?
இந்த திட்டத்தால் உங்கள் குறைபாடுகள் தீர்க்கப்பட்டதா? YES / ஆம் NO / இல்லை

Q3. Is this project packed with security features?
இந்த திட்டத்தில் பாதுகாப்பு அம்சங்கள் நிறைந்துள்ளதா? YES / ஆம் NO / இல்லை

Q4. Is this place properly maintained?
இந்த இடம் முறையாகப் பராமரிக்கப் படுகிறதா? YES / ஆம் NO / இல்லை

Q5. Whether the project meets the needs of the disabled?
இந்த திட்டத்தில் ஊனமுற்றோர் தேவையை பூர்த்திசெய்கிறதா ? YES / ஆம் NO / இல்லை

Q6. Is this place properly maintained?
இந்த திட்டம், எவ்வகை வயதினரை ஈர்க்கிறது?

1 Children / குழந்தைகள்
2 Student / மாணவர்கள்
3 Adults / பெரியவர்கள்
4 Senior citizen/முதியவர்கள்

Q7. In this project, what is impressed you the most?
இந்த திட்டத்தில், எது உங்களை வெகுவாக கவர்ந்துள்ளது?

_____

Q8. How useful this project is to you?
இந்த திட்டம் எவ்வகையில் உங்களுக்கு பயனுள்ளதாக அமைந்துள்ளது?

_____

Q9. What is your opinion about this project?
இந்த திட்டத்தை பற்றி உங்கள் கருத்து என்ன?

_____

_____

_____

B4

Solar Power Plant at Thanjavur Corporation, Sirajudeen Nagar

Location: *Sirajudeen Nagar, Thanjavur, Tamil Nadu*
Year of Project Implementation: *2017*
Sector: *Retrofitting and Redevlopment under ABD*
SDG: *SDG 7*
Project Cost: *46,409,070 INR*

Institute: *Dept. of Planning, Anna University*
Advisors: *Dr.K.Pratheep Moses, Mr.P.Sudharsanamurthy, Ms.K.Madhivadhani*
Students: *Sivamani P*

Keywords: *Smart city, Solar power plant, Renewable energy*

Abstract:

Renewable energy is a key to the sustainable future of tomorrow. The two cleanest sources of energy production are solar power and wind energy, both of which are seeing an increasing potential in different scales, residential level and at the national grid level. These renewable options are extremely promising in, not only in the clean (zero emissions) energy they produce, but also in what they can do for local economies.

This report focuses on one such project implemented in Tamil Nadu in the District of Thanjavur. Thanjavur city municipal corporation is amongst the ten cities under smart cities program in Tamil Nadu. With the development of non-conventional energy sources being an objective of the smart city program, Thanjavur corporation has proposed to develop a 3 MW solar park at Sirajudeen Nagar WTP. The proposed power plant at Sirajudeen Nagar WTP will have solar PV modules and string inverters as the major components and is to be developed under Long term open access method, by wheeling the produced power to captive consumption for the high-tension services availed by Thanjavur corporation from TANGEDCO.

The paper goes into great detail about the impact of the project by reviewing their strategies and implementation processes which focuses on the solar power plant as a part of the smart city goal. In this project, the Key Drivers for renewable energy includes the need to build energy security and the impetus provided by the global climate mitigation process. The Core Themes and priorities have been identified by the city administration post extensive citizen engagement and stakeholder consultations, which is a key feature of the Smart City Mission. The essence of the aspirations and priorities of its populace, the priorities and gaps emerging from the baseline assessment are reflected in its planning and visioning exercises.

The study is to understand and analyze the impact of the solar power plant and how it is been efficiently used by its stakeholders. The objectives of the study are to comprehend its efficiency, through analyzing the risks, challenges, learnings involved in this project and evaluate its replicability with respect to other cities.

Case Study: **B4**

1. Introduction

Thanjavur City is the headquarters of the Thanjavur District. The city is an important agricultural centre located in the Cauvery Delta and is known as the Rice bowl of Tamil Nadu. Thanjavur is administered by a municipal corporation covering an area of 128.02 sq. km and has a population of 2,90,720 in 2011. Roadways are the major means of transportation besides rail connectivity.

The city first rose to prominence during the reign of the Cholas, when it served as the capital of the empire. After the fall of Cholas, the city was ruled by various dynasties like the Pandya's, the Vijayanagar Empire, the Madurai Nayaks, the Thanjavur Nayaks, the Thanjavur Marathas, and the British Empire.

Thanjavur is located at 10.8°N 79.15°E. The tributaries of river Cauvery, namely, the Grand Anaicut canal (PudhThanjavurru), VadavThanjavurru and VennThanjavurru river flow through the city. Thanjavur is situated in the Cauvery delta, at a distance of 314 km (195 mi) south-west of Chennai and 56 km (35 mi) east of Tiruchirappalli. While the plains immediately adjoining the Cauvery River have been under cultivation since time immemorial, most of Thanjavur city and the surrounding areas lie in the "New Delta" – a dry, barren upland tract that was brought under irrigation during the early 19th century. To the south of Thanjavur city, is the Vallam table land, a small plateau interspersed at regular intervals by ridges of sandstone. The nearest airport is Tiruchirappalli International Airport, located 59.6 km (37.0 mi) away from the city. The nearest seaport is Karaikal, which is 94 km (58 mi) away from Thanjavur. The nearest seaport is Nagapattinam which is 84 km (52 mi) east of Thanjavur. The city has an elevation of 59 m (194 ft) above mean sea level. The total area of the city is 36.33 km2 (14.03 sq mi).

1.1 Topic and Context

As seen in Table 1 and Figure 2, the proposed 3 MW solar power plant at Sirajudeen Nagar WTP will have solar PV modules and string inverters as the major components and other accessories for power production. All the necessary auxiliary facilities of the power plant like plant monitoring system, safety equipment, instrumentation, control system, etc., will be provided for the power plant.

The water requirement for the module cleaning and other purposes will be met using the bore well at site. The proposed solar power plant is to be developed under long-term open access method, by wheeling the produced power to captive consumption for the high-tension services availed by Thanjavur corporation from TANGEDCO. On an average Thanjavur corporation pays Rs.4.1 crores per annum for the HT services. By installing a 3 MW solar power plant, Thanjavur corporation would save Rs. 2.8 crores per annum.

Site Name	District	Latitude/ Longitude	Area	Annual Average DNI (kWh/ m2/Day)
Sirajudeen Nagar	Thanjavur	10.47 / 79.09	12 Acres	5.34

Table 1 : Project description

1.2 Significance of the Project

In the 'Development of Solar Cities' program by the Ministry of New and Renewable Energy (MNRE), the Government of India is aiming at creating self-sustaining cities by leveraging the immense solar potential through renewable energy and several other energy efficiency projects in order to control conventional energy demand by 10% in the next five years.

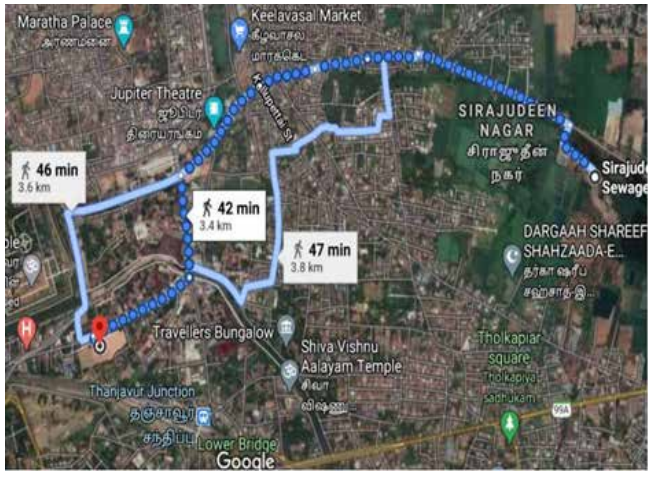

Figure 1.1: Proposed site distance from the TNEB

Figure 1.2: Project site

It is a well-known fact that electricity is the most essential input for the growth and development of any country. India is planning to grow rapidly and consequently, the demand for power is on the rise. However, the growth in installed power generating capacity has not kept pace with the projected demand.

1.3 Aim and Objectives

The aim of the study is to analyse the impact of the solar power plant and how it is efficiently used by the city. The objectives of the study are:

i. To understand the importance and need of the project.
ii. To study the processes of implementation of the project.
iii. To comprehend and examine its efficiency, through analyzing the risks, challenges, learnings involved in this project.
iv. To evaluate the project for its replicability to other cities.

1.4 Salient Features of the Site

i. The proposed Solar PV plant will be located at Sirajudeen Nagar WTP.
ii. The proposed site is located adjacent to the 110/11 KV substation near Court Road Substation. The distance from the substation to the proposed site is approximately 3.5 K.M.
iii. The total area available with the Thanjavur Corporation at Sirajudeen Nagar WTP is 24 acres out of which 12 acres are earmarked for the proposed solar power plant purpose.
iv. The proposed site is around 2.5 km away from NH 36.
v. The proposed site is 6.5 kms away from the Thanjavur Railway Junction, which is well connected with the major railway station
vi. The proposed site is 14 kms away from the Thanjavur central bus stand, which is well connected with the major cities of Tamil Nadu.
vii. The average solar radiation on the proposed site is above 5.34 Kwh/Sq. mt..

2. Contextual Background

Under the aegis of this Vision, Thanjavur has identified five Core Themes – Universal Access to Best-in-class Civic Services, Seamless Mobility, Sustainable Environment, Vibrant Economy, and Effective Governance – and priority goals under each of the Core Themes. Strategies have further been outlined under each of the 5 Core Themes to meet the priority goals. The Core Themes and goals are defined so as to capture:

i. The essence of aspirations and priorities of its populace
ii. The priorities and gaps emerging from the baseline assessment
iii. The ideas reflected in its planning and visioning exercises

The Core Themes and priorities have been identified by the city administration with extensive citizen engagement and stakeholder consultations, which is a key feature of the Smart City Mission. It is therefore evident that the city as a whole places high emphasis on achieving and maintaining a Sustainable Environment, which is one of the Core Themes identified. The priority strategies outlined under the Sustainable Environment theme further demonstrate that, Coimbatore recognizes the need to take action towards addressing energy use and climate change.

Thanjavur is committed to promoting renewable solar and wind energy, reducing energy consumption by implementing renewable energy and energy efficiency-related actions identified under its Solar City Plan, along with building its resilience towards Climate Change. The city remains keen to improve the quality of its air and water resources and promote water reuse as well.

2.1 Key Features of the Project

i. The proposed solar plant shall lead to the reduction of power bills by supplying solar power to local electricity suppliers. This is the need of the hour for all urban local bodies.
ii. The proposed 3 MW solar power plant at Sirajudeen Nagar WTP will have solar PV modules, string inverters as the major components & other accessories for the power production
iii. Facilities of the power plant like plant monitoring system, safety equipment, instrumentation, control system etc., will be provided for the power plant.
iv. The water requirement for the module cleaning and for other requirements can be met from the bore-well at the site
v. The proposed solar power plant is to be developed under Long term open access method, by wheeling the produced power to captive consumption for the high-tension services availed by Thanjavur corporation from TANGEDCO
vi. On average Thanjavur corporation pays Rs. 4.1 crores per annum for the HT services. By installing a 3 MW solar power plant, Thanjavur corporation would save Rs.2.8 crores per annum

2.1.1 Challeneges in The Project

i. The deficit in the installed capacity as well as in the potential availability provides ample justification for the installation of 3 MW (DC) power plants at Sirajudeen Nagar WTP compost yard apart from providing power, these solar power projects in the surrounding will be advantageous to the local community in the following ways:
ii. Solar power project purely depends on the collection of solar radiation.
iii. The solar collector panels are required to be maintained by regular cleaning, resulting in direct employment generation.
iv. The average HT category power consumption of THANJAVUR Corporation is around 5,14,800 units/ Month (Annual: 6170 MWh / year) and it is projected to increase by 150 % because of the new projects in the pipeline

2.1.2 Risks involved in the project

The solar plant shall require about 1 ML of water per year, which is mainly for cleaning the solar PV panels. Since the requirements are less, this will be met from ground water. Water harvesting system and also borewell rejuvenation system shall be installed at the site to replenish the ground water. The proposed site has to be connected with a 30 ft main road on both sides of the boundary.

There are many technologies and options available for generation of solar power. The options include:

i. Solar PV system.
ii. Concentrating Solar Power (CSP) technology.

So, the decision has to be clearly made with the consultancy.

Jan	Feb	Mar	Apr	May	Jun
5.31	5.89	6.27	6.22	5.69	4.70

Jul	Aug	Sep	Oct	Nov	Dec
4.93	5.42	5.25	4.99	4.50	4.97

Average
5.34

Table 2: Monthly Averaged Insolation Incident on A Horizontal Surface (kWh/m2/day)

After studying the Table 2, the site is said to have an annual Global Horizontal Irradiance (GHI) of 5.34 kWh/m2 /day. The basic instrument packages for making site-specific solar resource measurements or for instrumenting a solar energy conversion power plant, to support operational needs for system performance and, or solar resource forecasting are required.

The configuration requires a location for the instruments that provides good daily solar access throughout the year. This should be an area with a clear horizon without any obstructions that might shade the instruments or introduce reflected solar radiation (for instance, building roof is a good location). The location should also have safe and secure access, which is required for regular equipment inspections.

2.1.3 Features and Benefits to the city

To reduce the electricity bill for the municipality, which was the main aim of the project in feature the cost estimation electricity shall get reduced by this solar power plant project. Direct capital cost shall involve such expenses, that are required to be made upfront in order that the system is procured from the market.

Based on international studies and considering the current market trend, the costing of the PV plant is worked out. The total cost of the system works out to be INR 4,60,00,000 for 1 MW excluding GST. The indicative cash flow of the power plant shows that payback period is 6.5 years without depreciation.

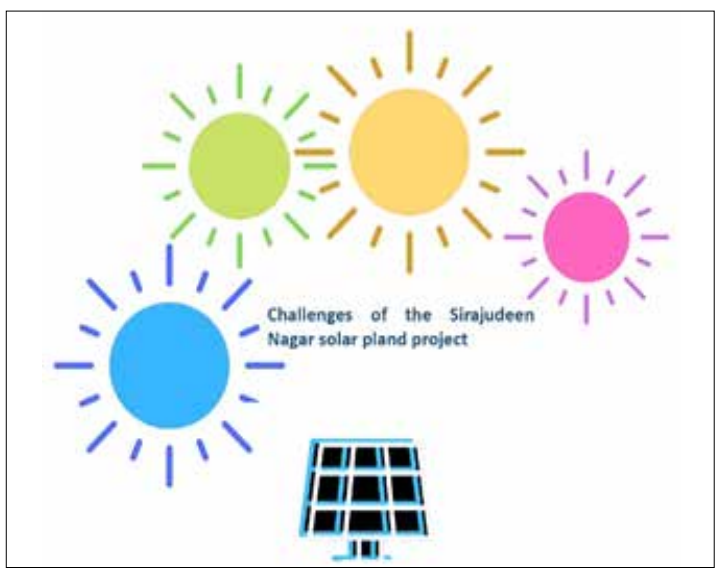

Figure 2.1 : Challenges of the project

Figure 2.2 : Challenges of the project

2.1.4 Key Findings from The Interviews, Surveys, and Primary/ Secondary Data Collection

Personal interviews and surveys were conducted with the local stakeholders and also the administrative stakeholders, who are the direct beneficiary of this project. The survey questionnaire is given in Annexure Based on the discussions, the following are the key findings of the solar power plant project.

The municipal corporation is the beneficiary of this project as the electricity generated is used by the local body in addition for day-to-day activities like street lights, water pumping stations, and government buildings. If the municipality get benefits from this project, the people also automatically get benefited from this solar power plant project.

i. Main user: Municipality
ii. Secondary benefits: People

On average at Thanjavur, the corporation pays Rs 4.1 crores per annum for the HT services. By installing a 3 MW solar power plant, Thanjavur corporation would save Rs. 2.8 crores per annum. The aim to reduce power bills by supplying solar power to local electricity suppliers is the need of the hour for all urban local bodies.

Direct capital cost involves such expenses which are required to be made upfront in order that the system to be procured from the market. Based on international studies and considering the current market trend, the cost of the PV plant is worked out. The total cost of the system works out to be INR 4,60,00,000 for 1 MW Excluding GST. The indicative cash flow of the power plant shows that the payback period is 6.5 years without depreciation.

Though there is no shortage of electricity supply in the municipality, the main aim of the project is to reduce the electricity bill through energy security with the way of a solar power plant in a sustainable manner. So, the solar plant is implemented in the city.

2.1.5 Why solar power plant?

Thanjavur has a hot and dry climate, making the solar plant much more suitable for Thanjavur for nearly 8 months of the year.

3. Discussion and Conclusion

Energy Security refers to the loss of economic welfare that may occur as a result of a change in the availability of energy. This project helps to ensure energy security. The solar power plant project is one of the essential projects that helps the government to directly render to the energy needs of the citizens.

3.1 Implications

Under its Pan-city proposal, outlining the implementation of smart solutions across the city, Thanjavur plans to refurbish its street lighting with energy-efficient light-emitting diode (LED) street lights and equip these with surveillance cameras and Wi-fi facilities to bolster the connectivity to help in efficient smart traffic management, provide seamless connectivity, prevent crime/ accidents, enable expeditious emergency and disaster response. Installation of air quality monitoring systems is planned across the city.

3.2 Limitation of the research

The study focuses on reviewing of the project implementation process by assessing the transformation between the before and after implementation of the interventions and how to deal with the concerns in the city. The study focuses on the implementation strategies, operational features, and strategic plans which were crucial in driving the change. The study is based on taking into account the technical, financial, public, and social aspects of this project.

3.3 Key lessons learnt

Electricity demand in the buildings sector has risen at an average rate of 8% per year from 2000 to 2013. Hence, the solar plant project has to be promoted on a micro and macro scale.

A key feature of the Smart City Mission is laying high emphasis on achieving and maintaining a Sustainable Environment, which was one of the Core Themes identified by the Thanjavur municipal corporation.

Thanjavur is committed to promoting renewable solar and wind energy, reducing energy consumption by implementing renewable energy and energy efficiency-related actions identified under its Solar City Plan as shown in Figure 3.2, and building its resilience toward Climate Change. There are two key dimensions to energy security one is reliability and another one is resilience.

i. Reliability means the ability of Users to access the energy services when they require them
ii. Resilience is the ability of the system to cope with shocks and change

3.4 Recommendations

Now that the proposal has been made, it is being directly used by the government. Its features directly impact the beneficiaries.

Alternative expensive technology such as PV cells would be needed for future interventions.

The solar plant requires about 1 ML of water per year, which is mainly for cleaning the solar PV panels. Thus, recycled water can be used for cleaning purposes to reduce the water burden.

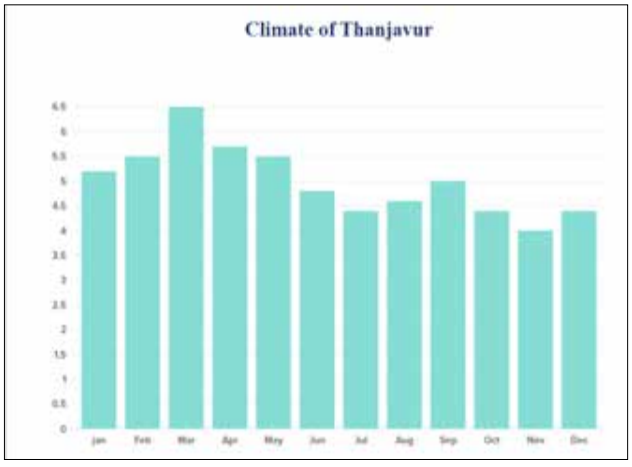

Figure 2.3: Climate bar chart

Figure 2.4: Climate bar chart

Figure 3.1: Climate bar chart

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ANNEXURE 1
QUESTIONNAIRE FOR ON-SITE SURVEY

Smart Cities and Academic towards Action & Research program (SAAR)

Who is the user of this project?

.....

.....

.....

What is the main aim of the project?

.....

.....

.....

How much amount has to be saved from this project?

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.....

.....

What is the payback period of this project?

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.....

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What is the energy demand and why it's needed?

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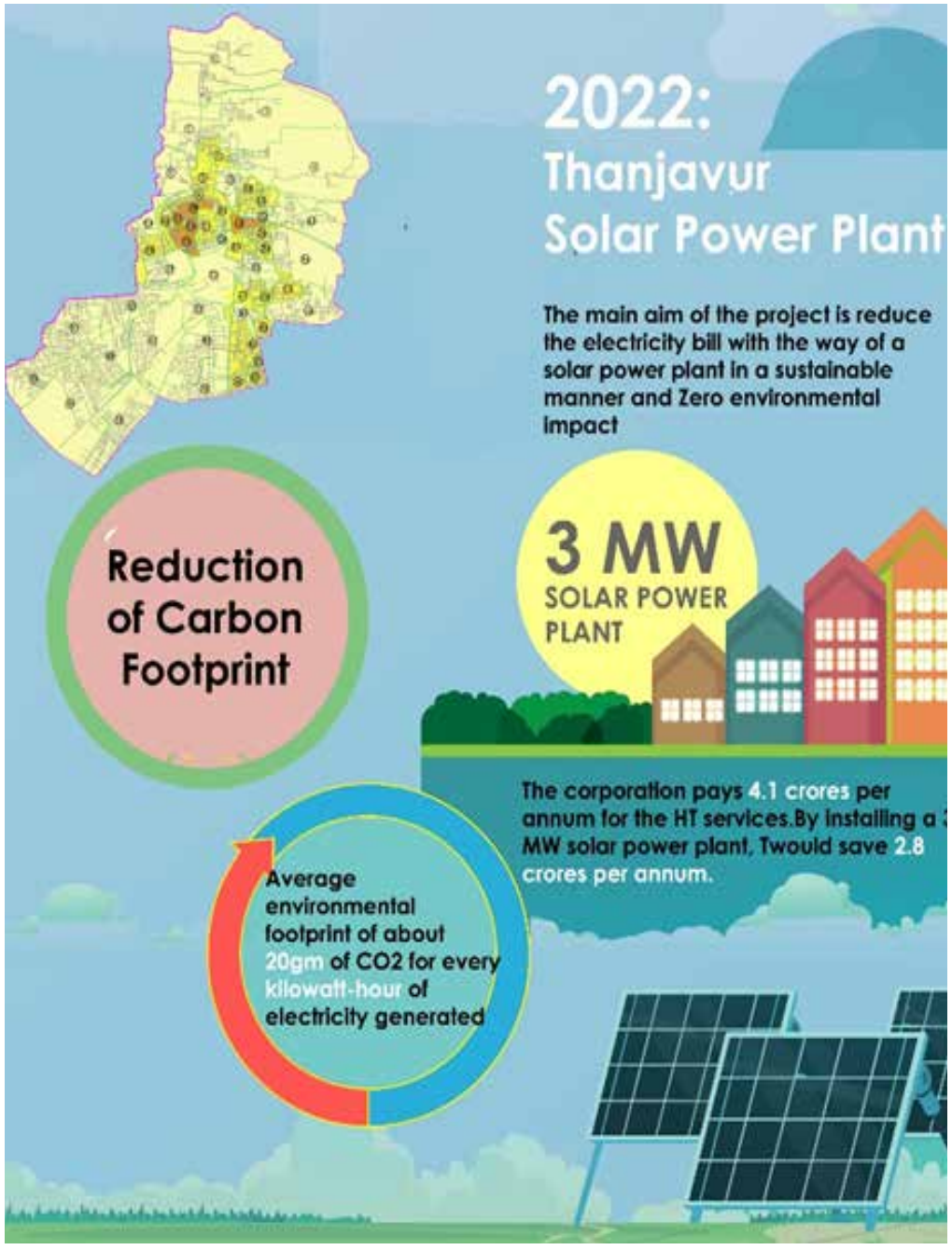


Figure 3.2: Outcome Infographihcs

B5

Green Future Solutions: Roof Top Solar

Name of the project: *Green Future Solutions - Rooftop Solar Systems*
Location: *Dharamshala, Himachal Pradesh*
Year of project implementation: *2018*
Sector: *Renewable Energy*
Project Cost: *Rs 2.14 crore*
Linkages to SDGs: *SDG 7*

Institute: *Indian Institute of Technology, Roorkee*

Advisors: *Mentor: Mr. Sagar Sinha, Faculty Coordinator: Dr. Arindam Biswas*
Students: *Mr. Alok Shakya*

Keywords: *Renewable Energy, Green Solution, Solar Energy, Solar Panels*

Abstract:

Dharamshala[1] is a beautiful hill town with seasonal tourist attractions. For water supply, this region is served by the Fluvial Himalayan Glacier. The glacier also provides a scenic rich environment with snow-capped mountains. Dharamshala was chosen to become a Smart City. The Smart Cities Mission is to promote economic growth and improve the quality of life of the citizens by enabling local development and use of technology.

Under the Smart City Plan in the ABD area of Dharamshala, providing rooftop solar systems for green future solutions have been proposed. To achieve energy security and good optics, it is planned to develop large-scale Solar Rooftop Projects by utilising vacant roofs of buildings and adjoining lands of the campus, among other areas. Green energy is an essential factor to consider while planning a city. Green Future Solutions in Dharamshala is the primary emphasis of this study. It examines the current state of roof-mounted solar systems.

[1] *Author: Alok Shakya (MURP I Student)*
Mentor: Sagar Sinha (Phd Scholar)
Faculty Coordinator: Dr Arindam Biswas

Case Study: **B5**

1. Introduction

Dharamshala, a town in the Indian state of Himachal Pradesh, is located at the foothills of the Himalayas. Dharamshala is divided into two sections: Upper and Lower Dharamshala. Lower Dharamshala refers to Kotwali Bazaar and regions lower down into the Kangra valley (at an average elevation of 1,250-m), whilst the Upper Dharamshala refers to McLeod Ganj and its surrounding areas on the hillside (at an elevation of almost 1,800-m). Dharamshala is best described as an "exquisite, engaging and strange" region. Dharamshala is Himachal Pradesh's spiritual capital and the state's second capital. There are several aspects of this picturesque hill station that draw visitors from both within and beyond the country. It is an ideal place for vacations both due to tranquillity and adventurous travellers.

The Himachal State Government recommended Dharamshala to the Ministry of Urban Development (MoUD) to develop it as a Smart City. Dharamshala city has chosen the brand name and logo "Divine Dharamshala" as part of the submission process. "Divine Dharamshala" depicts the city's power, which stems from its rich natural and cultural legacy, as well as its people. To capitalise on the city's existing characteristics of divinity, calmness, tranquillity and beauty, it was nominated for the Smart City Mission.

Vision 2025 for Dharamshala was formulated as "A global tourist destination for all reasons and all seasons which is sustainable, resilient and smart while being, for its residents, a city which is liveable, economically vibrant, safe and inclusive".

The Area-Based Development (ABD) project for Dharamshala is based on the conclusions of the public engagement process and on the strategy of redevelopment and retrofitting development over 775 acre of land encompassing a population of 27,053 people (50 percent of the city's total population). Dharamkot, Bhagsu, McLeod Ganj, Kotwali Bazar, Khajanchi Mohalla, Kachahri Adda, Ramnagar, Shyamnagar and Cheelgari are some of the prominent localities.

1.1 Topic and Context

As global climate change has become a significant concern in recent years, there has been a greater push for the use of clean and renewable energy sources. This is due to a significant increase in the Earth's surface temperature which has increased by 0.6° - 2°C since 1900 (Hughes, 2003). Carbon emissions from combustion of fossil fuels (coal, oil and natural gas) to generate power are the most significant contributors to this shift in global climate (USEPA, 2017).

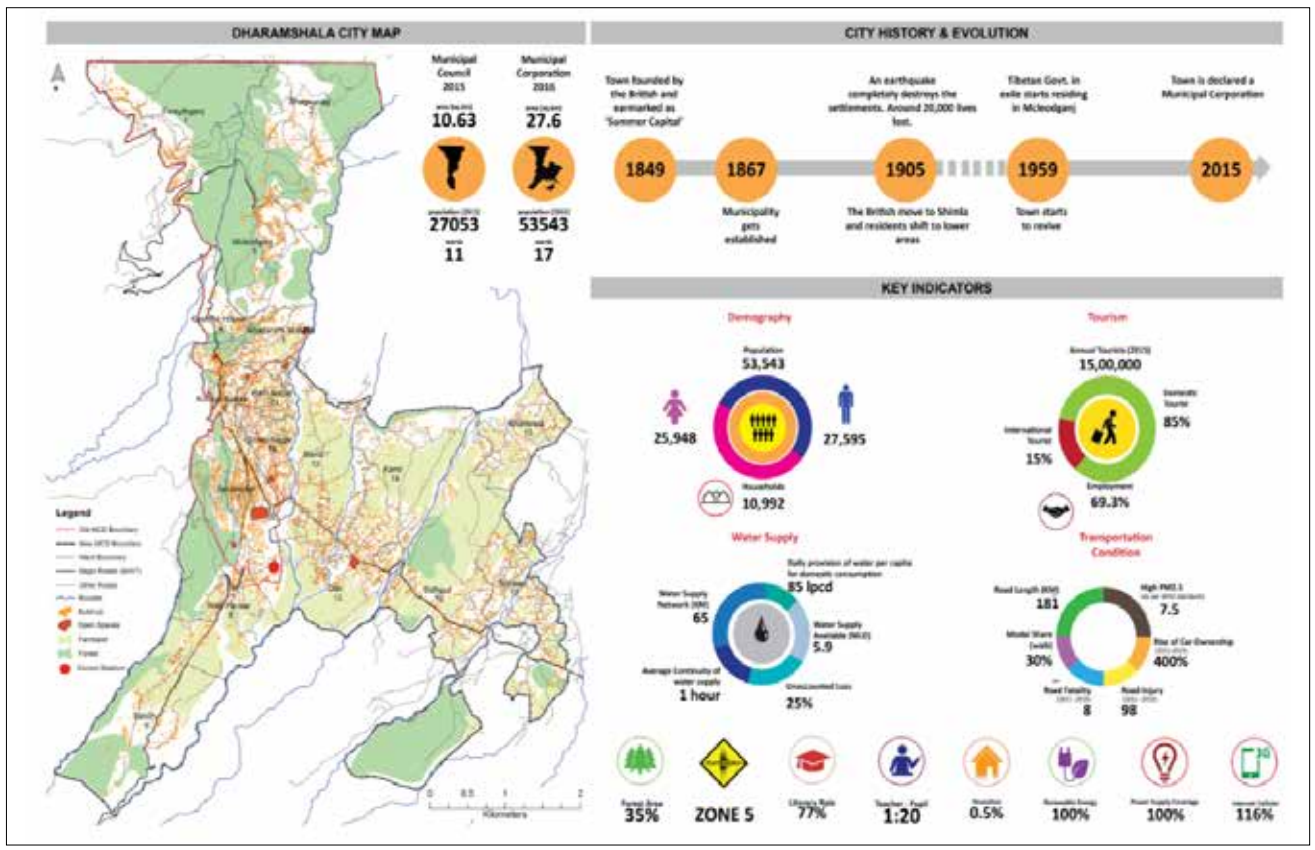


Figure 1. Dharamshala City Profile
Source: Municipal Corporation Dharamshala

The project comes under the Renewable Energy Sources Programme and the Green Future Solutions Rooftop Solar Systems in Dharamshala region. Dharamshala is situated on a hill, surrounded by mountains. Himachal Pradesh is bestowed with perennial water resources. All these circumstances are perfect for hydropower facilities to generate electricity. Hydropower plants are Dharamshala's primary source of energy. Some are government-sponsored while others are owned by private individuals. Hydropower generation is also regarded as a renewable energy source.

1.2 Scope of the project

Green energy is urgently needed to minimise carbon footprints and protect the planet from global warming. With growing power rates, switching to renewable energy mode will lead to significant savings for both short and long-term green energy goals. The Indian government has declared the National Solar Mission as part of its green energy programme. This mission's purpose is to install 100 GW of solar electricity by the year 2023. The Indian government has established the Smart Cities programme under which 100 cities will be developed.

Solar power plants have to be constructed in each nominated city as part of the integration of the National Solar Mission with the Smart City Mission. Depending on the topography of each place or region, prospective Solar PV installations must be determined. The initial point of focus for Rooftop Solar installations is government buildings and public infrastructure. Dharamshala's climate is ideal for harnessing solar energy.

1.3 Significance of the project

According to the Smart City Guidelines, a Smart City should generate at least 10% of its power from renewable sources. So, in Dharamshala, at least 10% of the energy needs to come from renewable sources. To boost the number of renewable energy sources, the city is implementing long-term strategic programmes to harness the renewable energy sources in its region. In the state, renewable energy solutions such as solar thermal, solar PV and small hydro plants have tremendous promise. Currently, solar and small hydro plants account for more than 100% of all energy sources in Himachal Pradesh, including Dharamshala. The state's electricity policy focuses on increasing the capacity of solar and small hydro choices (HIMURJA, 2016).

The primary goal of the solar rooftop project is to strengthen infrastructure in order to improve the quality of life of the citizens and provide a stable and ecologically sustainable electricity supply.

1.4 Aim and Objectives

The aim of the study is to analyse the impact of the Solar PV Panel System in Dharamshala.

The objectives of the study are:

i. To assess the impact of the Solar PV System on the city and the challenges involved in the process
ii. To analyse the role of Solar PV Systems developed by the Smart City Mission in saving energy

2. Contextual Background

Himachal Pradesh, being a mountainous state, has typically clear skies and the average solar radiation level throughout the state's physiographic zones gets insolation between 4.00 - 5.25 kWh/m2/day with over 300 clear sunny days per year, encouraging commercial and residential solar energy applications. Solar Photo Voltaic (PV) is the other most suited renewable energy alternative for electrical power generation, according to Dharamshala's Solar Radiation and Temperature statistics (SPV). The optimal temperature for SPV modules is 25°C. Weather records from the past show that the usual average temperature in Dharamshala is less than or equal to 25°C.

The power distribution system is one of the most important systems in any city. There are different ways through which electricity is distributed in cities such as Thermal Power plants, Hydropower plants, Nuclear Power plants etc. These systems are sufficient but due to rising urbanisation and evolving demand for increased power supply the power distribution network is encountering new problems. The increasing requirement for implementing innovative and intelligent technologies to provide Smart City Infrastructure necessitates an increase in network automation.

2.1 Power Generation in Himachal Pradesh

In terms of the state's solar potential, there is almost no accurate calculation of potential available/achieved, especially given the expanses of frigid desert in Lahaul and Spiti and a part of Kinnaur district in the Trans Himalayan region. The primary obstacle in capturing solar power in Himachal Pradesh is that sites with high-intensity radiation are unknown. Solar power is costly when compared to Hydroelectric Power, which has enormous potential in this state. Unlike in many other states, even discounted rates of power per unit are not profitable for domestic purchase in HP. The chilly desert area of Lahaul and Spiti districts, as well as a portion of Kannur districts, lacks effective electricity evacuation (a facility that permits produced electricity to be quickly transported from a producing unit to the grid for further transmission).

The state has a hydropower potential of 25,000 MW, which includes 2300 MW of small hydro capacity classified as a renewal source. A total of 10,000 MW of power is presently operational, with another 8000 MW in different stages of construction. The present net annual consumption (net of T&D losses) is roughly 8500 MWs, with a peak demand of 1400 MWs. The Himachal Pradesh State Electricity Board Ltd (HPSEBL) has adequate long-term committed supplies available from its own stations, CPSU stations, Himachal Pradesh Power Corporation Limited (HPPCL) sources, State government's equity share in the Joint Sector projects and free power from hydro projects which will remain surplus in the foreseeable future. Himachal Pradesh has a lot of hydro potential, but hydroelectricity has its own set of expenses.

The ecological disruption is caused by sinking land and interfering with the natural water flow. Watershed Management with downstream riparian states - rivers in India are on the concurrent list, thus, both the state and national governments have jurisdiction, resulting in a slow decision-making process. Submergence of land has its own cost that is aggravated due to the large population density of India. Dam construction is not permitted on all sites because the region around the Himalayas is seismically active. There may be a possibility of balancing solar generating objectives with non-renewable energy output. The solar power generation should be better because temperature in the Himalayas is cooler, resulting in improved performance of silicon cells and cleaner air for better solar insolation.

Himachal Pradesh has set an ambitious goal of improving its solar power infrastructure. Even though Himachal Pradesh is not the easiest state for establishing solar power projects, the government has set a target of installing 700 MW of solar power capacity under its updated strategy. The state government has amended its solar power programme in view of the national government's increased solar power objective of 100 GW operational capacity by March 2022. According to the Ministry of New and Renewable Energy, Himachal Pradesh should have an installed capacity of 776 MW by March 2022 in order to meet this national objective.

Himachal Pradesh has the highest Renewable Purchase Obligation (RPO) objective of any Indian state. In order to meet its RPO, the state must grow its installed solar power capacity. By 2022, the state intends to supply at least 19% of its entire electricity consumption from renewable energy sources, including 3% from solar power plants. On the other hand, the government has increased the solar RPO target to 8% by 2022.

Himachal Pradesh's geographical location does not allow for large-scale Solar Power plants like those found in India's western and southern regions. Therefore, the government prioritised Rooftop Solar Power projects and dispersed those projects that were developed in association with farmers and jobless youth. Medium-sized projects with a capacity of up to 100 MW, contributing to the Solar Power plants under the central government's programme, is also encouraged. The national government has authorised 1 GW of solar power in Himachal Pradesh as part of its ultra-mega Solar Power projects plan.

2.2 Himachal Pradesh Solar Power Policy 2016

According to this policy, electricity consumers of HPSEBL will be eligible to install a minimum of 1 KW to a maximum of 5 MW capacity Solar PV plants on their building's rooftop or premises, which will be connected to the grid with bi-directional metres. The consumer will use solar power for her/his consumption and the surplus generation will be sold. The Himachal Pradesh Solar Power Policy applies to Solar PV Technology and is active until 31st March 2022, unless updated or extended. This strategy aims to encourage the use of solar energy to generate power. The State Government developed its Solar Power Policy, published on 4th March 2014. The Government of India has increased the capacity objective from 20,000 MW to 100,000 MW (100 GW) by 2022, with 40 GW projected using the rooftop method.

While there is enough renewable energy generation through Small Hydro Powers (SHPs), it is preferable to align the state's aim with the national target. The HPSEBL can meet its Renewable Power Purchase Obligation (RPPO) by acquiring power from outside the state as well as Renewable Energy Certificates (REC). The goal of energy security and sustainability can only be attained if the tremendous capacity available in the state is utilised inside the state. This will improve the system's efficiency, quality and equity of access. Considering this, policy changes are necessary for which solar project investments are considered, and the government becomes a partner in development by facilitating statutory clearances and providing administrative assistance and consent in a timely way (HIMURJA, 2016).

3. Existing Electricity Power Sources

Dharamshala is situated on a hill, encircling the mountains. Himachal Pradesh has a steady supply of perennial water resources. All these circumstances are perfect for the generation of electricity by hydropower plants, which are Dharamshala's primary source of electricity. These plants are found all over the place. Some are government initiatives, while others are privately held. In Kangra district, there are several Hydroelectric Power Stations managed by Himachal Pradesh State Electricity Board (HPSEB), National Hydroelectric Power Corporation (NHPC) and other private players. The Gaj and Baner hydroelectric power stations are in Kangra district, near Dharamshala. The HPSEB oversees both these power stations.

The Gaj Hydroelectric Power Station features three turbines with a combined capacity of 3.5 MW. This power station has a total capacity of 10.5 MW. This power plant's overall output will be 10.5 MW if all three turbines are operational. This power plant's transmission voltage is 33 kV. Baner Hydroelectric Power Plant is the other government hydroelectric power station. There are three turbines in this power facility. Each turbine has a capacity of 4 MW. Cumulatively, this power station produces 12 MW and uses a 33 kV power evacuation system.

The Hydroelectric Power Plant is affected by fluctuating water levels throughout the year. This scenario of shifting water levels has an impact on electricity generation as well. The basic information about both power plants is mentioned in Table 1.

Sl. No.	Parameter	Baner	Gaj
1.	Total Capacity	12	10.5
2.	No. of Turbines	3	3
3.	Capacity of each Turbine	4	3.5
4.	River	Baner Khad	Gaj Khad
5.	Owner	HPSEB	HPSEB

Table-1. Existing hydroelectric power sources in Dharamshala
Sources: Rooftop solar detailed project report

The consistency of power levels is hampered as a result of this. The infrastructural needs and costs of upkeep are also significant. Changing the path of the natural water flow can have a negative impact on the ecosystem and climate change. These circumstances have the potential to contribute to global warming. There is a need for an alternate method of renewable energy generation to avert these negative consequences on the environment. This renewable energy source must be compatible with the present infrastructure and it will be placed in a dispersed style and will not necessitate additional electrical infrastructure.

3.1 Hydroelectric Power System

Hydropower is one of the least expensive ways to create energy, and it is utilised by more than 60 nations throughout the world, supplying half of their electrical demand. It also has the added benefits of being a clean energy source, supplying electricity "on-demand," and creating thousands of employees worldwide. Hydropower is energy produced by water sources such as oceans, waterfalls and rivers. Water is an unlimited resource and its cycle provides an infinite recharging system, making it a renewable energy source. Hydropower works by capturing the energy that flows through a turbine attached to a generator and converting it into electricity. Most hydropower facilities store water at a dam which is regulated by a gate or valve to monitor how much water comes out. The higher the dam's height, the more energy may be generated. Water accumulates potential energy just before it passes over the dam, which is translated into kinetic energy as it runs downhill. Water is used to operate a turbine which is linked to an electric generator and which delivers power to end customers.

3.2 Disadvantages of Hydroelectric Power System

i. **Limited Plant Locations -** While hydropower is a renewable energy source, there are only a few areas on the planet where plants can be built. Furthermore, several of these locations are also not close to big cities which would primarily benefit from the energy.
ii. **Higher Initial Costs -** While no power plant is simple to construct, hydroelectric facilities need the construction of a dam to stop the flow of water. As a result, they are more expensive than comparable-sized fossil fuel facilities. However, they will not be required to purchase fuel in future. As a result, it balances out in the long run.
iii. **Carbon and Methane Emissions -** While the plant itself does not emit any pollutants, the reservoirs it creates do. Plants emit carbon and methane when they decease. Plants at the reservoir's bottom start decomposing, leading to emissions.
iv. **Susceptible to Droughts -** While hydropower is the most dependable renewable energy source, it is limited by the amount of water available in any given region. A drought might thus have a substantial impact on the functioning of a hydro plant. As Earth continues to heat up due to climate change, this may become more regular.
v. **Flood Risk -** When dams are erected at higher heights, they pose a major risk to any local community that lies below them. Even though these dams are quite powerful, there are still concerns about potential dam structural failures.

Figure 2. Gaj hydroelectric power plant
Source: https://www.swapdial.com/public/knowledge-contents/industrial-data/gaj-hydroelectric-project/

Figure 3. Baner hydroelectric power plant
Source: https://banerhydropowerhouse.wordpress.com/introduction/

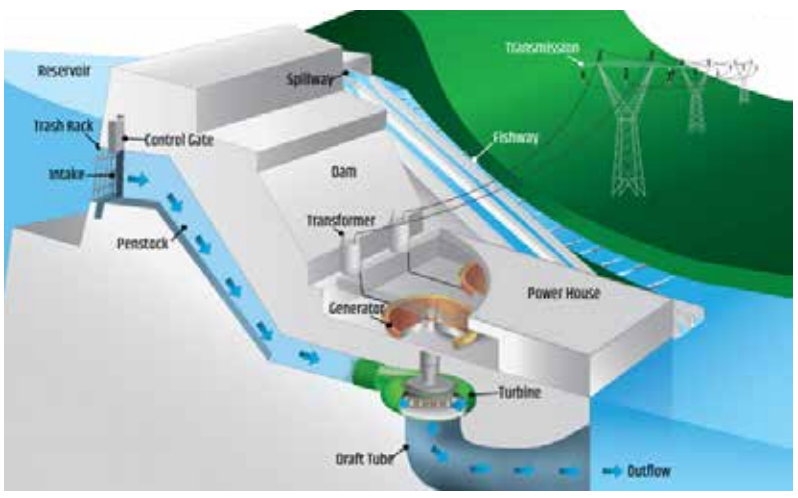


Figure 4. Hydroelectric power plant system
Source: https://www.energy.gov/eere/water/types-hydropower-plants

3.3 Solar PV System

Solar Power Systems use the sun's free, renewable energy. A solar-powered grid connection technology provides clean electricity via roof-mounted panels. This can be consumed or supplied back into the power system. A net meter is put to track electricity generation and consumption. When the sun shines on the solar panels linked to the solar power systems on the roof, "direct current" (DC) energy is created. This DC power is supplied into a solar inverter which transforms it into alternating current electricity. Appliances can utilise the same electricity as the mains. Any excess electricity generated by the solar power system that is not consumed by appliances, is routed back into the main power supply grid.

3.4 Orientation of Solar PV Modules

The efficacy of solar panels is determined by the direction in which they are oriented. In Dharamshala, South-facing is preferred for the solar panel orientation. They should be aimed squarely towards the sun, at a proper angle and without any shade from trees or other structures.

3.5 Advantages of Solar PV System

i. **Highly Reliable -** Even in adverse situations, **Photo Voltaic (PV) systems** remain very dependable. Photo Voltaic arrays provide ongoing, uninterrupted functioning of important power supply.
ii. **Strong Persistence -** Most modules in a PV system have a guaranteed duration of up to 25 years and continue to function even after many years.
iii. **Low Maintenance Cost -** This system requires routine inspections and minor repairs, which are incredibly low in comparison to traditional fuel systems.
iv. **Zero Fuel Consumption -** This system does not require fuel and can save money on procurement, storage and shipping.
v. **Less Noise Pollution-** This system runs silently with a little mechanical action.
vi. **Strong Security -** This system does not require fuel and may be safely operated after design and installation.
vii. **Strong Independence -** Many residential regions are adopting this new technology since Photo Voltaic systems preserve energy independently and are thus unaffected by utilities.

4. Existing Solar PV System in Dharamshala

Some government buildings in Dharamshala have Solar PV systems installed on their rooftops. The Dharamshala Municipal Corporation Building in Dharamshala's Kacheri Adda is one such example. The Solar PV system has a capacity of 4 KW and is battery powered. A Power Conditioning Unit (PCU) is included in this system. This Photo Voltaic (PV) Solar system is presently inactive. Both the inverter and the Power Conditioning Unit (PCU) are turned off.

S. No.	Location	Capacity	Battery
1	Rooftop of Municipal Corporation building, Dharamshala	4 KW	Yes

Table-2: Existing Solar PV System in Dharamshala
Source: Rooftop solar detailed project report

The other Solar PV system installed is a Compact Fluorescent Lamp (CFL) based on solar street lights, which appear to be partially operational due to incorrect orientation which eventually leads to a damaged battery and finally failure.

4.1 Identification of buildings for installing Rooftop Solar

The rooftops of government buildings are inspected in accordance with the Smart City requirements such as open and clean roofs and no shadows of trees on roofs.

This study is being carried out to evaluate the capacity of Solar PV Power Plants that can be erected. This estimate is based on the orientation and area/space available on the selected building's rooftop. In Dharamshala, more than 60 structures were surveyed. The survey was conducted for rooftops as well as open spaces controlled by the government. These regions are being assessed for potential Solar PV Installations. Majority of Dharamshala's rooftops are inclined at an angle from two or more sides. These roofs are primarily intended to minimise snow accumulation during snowfall. The typical roof types found in Dharamshala are shown in the figures below:

Some of the rooftops are open and oriented southward, which is ideal for maximising sunshine, but others are enclosed by trees on two or more sides. In comparison to a flat roof, the inclined roof significantly lowers the space accessible for the Solar PV systems. The trapezoidal form of the faces of these types of roofs significantly restricts the space accessible for Solar PV Installation. If one of the roof's faces is angled southward, it becomes favourable.

Although electricity is accessible in most sections of the city for most of the day, certain regions are not as well supplied. According to statistics from the HPSEB, the city's power supply network covers 100% of the area. In 2014, Dharamshala's power consumption exceeded 57 million units with a high demand of 26.46 MVA, with residential usage accounting for about 87% of total consumption. Rain and snowfall are very frequent natural occurrences. During such weather, the likelihood of power outages rises because of lightning and wind flow, threatening energy support infrastructure e.g. dams, electricity poles, etc.

4.2 Project Implementation

According to Dharamshala Smart City, the project has to

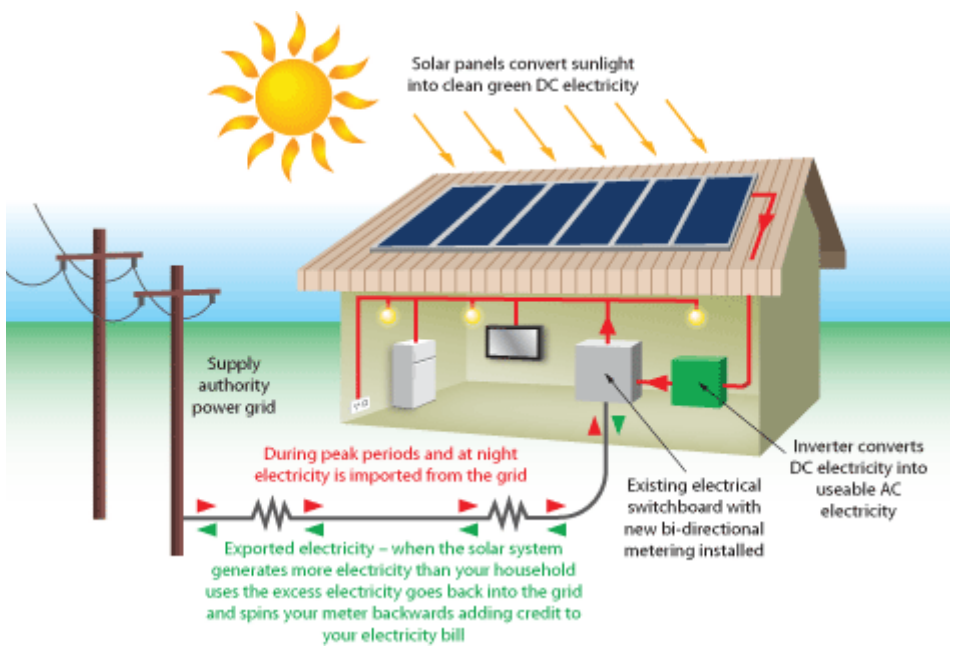


Figure-5: Grid-connected rooftop solar system
Source: https://springviewz.com/solar-power-systems/

Figure-6: Solar PV module on the rooftop of Municipal Corporation building of Dharamshala
Source: Rooftop Solar detailed project report

be implemented in three phases. After the identification of buildings for installing Solar PV Panel Systems, the implementation is done in two phases:

Phase I

The grid-connected Solar PV Power plants of capacity 340.23 KW were installed on four government buildings in the first phase of this project, based on their sanctioned load (contract demand) and availability of sunny sites.

Table 3. Solar PV System installed in Phase I

S. No.	Place or Building Name	SPV Capacity (KWp)
1.	Indoor Sports Complex	20.13
2.	Community Hall	20.13
3.	HPBSE	99.99
4.	Zonal Hospital a) Old Building b) OPD Building c) Blood Bank Building	 102.96 48.51 48.51
	Total	340.23

Source: Dharamshala Smart City

The work on the first phase of the Solar PV system was awarded on 27th November 2018. The operation started on 18th October 2019.

Phase II

The grid-connected Solar PV Power plants of capacity 110.55 KW were installed on six government buildings in the second phase of this project based on their sanctioned load (contract demand) and availability of sunny sites.

Table 4. Solar PV system installed in phase-II

S. No.	Place or Building Name	SPV Capacity (KWp)
1.	Superintendent of Police, Kangra	10.05
2.	D.R.O.C Block	20.10
3.	Tehsildar	20.10
4.	ADM Kangra	20.10
5.	DC Kangra/Sugam Centre	20.10
6.	Divisional Commissonar, Kangra	20.10
	Total	110.55

Source: Dharamshala Smart City

The work on the second phase of the Solar PV System was awarded on 20th January 2020. The operation started on 10th December 2020. The total capacity of all the Solar PV systems installed in phase I and phase II are 450 KW.

Phase III

After successfully installing the Solar PV Systems on government buildings for phase I and phase II, 1000 KW is further planned to be installed on the location sites of the below mentioned 25 government office buildings in the third phase of this project based on their sanctioned load (contract demand) and availability of sunny sites. The approximate budget for phase III is Rs 5 crore and the work is likely to be tendered before 31/03/2022.

Table-5: Project status as on 28th February 2022

S. No.	Phase	Capacity (KWP)	Project Status	Generating Power Since
1	Phase-I	340.23	Completed	18 October 2019
2	Phase-II	110.55	Completed	10 March 2020
3	Phase-III	1000	In progress	In progress

Source: Dharamshala Smart City

Figure-7: Inclined roof of the Municipal Corporation Dharamshala
Source: https://www.tribuneindia.com/news/himachal/battle-lines-drawn-for-dharamsala-mc-poll-229026

Figure-8: Open air jail surrounded by trees
Source: Rooftop Solar detailed project report

Figure-9: Fire station with trees on both sides creating shadows
Source: Rooftop Solar detailed project report

Figure-10: Inclined roof of hotel Kunal with trees in the rear
Source: Rooftop Solar detailed project report

Figure-11: IPH reservoir with flat rooftop
Source: Rooftop Solar detailed project report

Figure-12: IGNOU building with small roof area and inappropriate orientation
Source: Rooftop Solar detailed project report

5. Conceptual framework / Research design

5.1 Key features of the projec

5.1.1 Challenges in the project

i. Mountains and forests on the southern, eastern and western sides reduce power generation
ii. Trees create shadows on rooftops which makes a solar system less effective
iii. Due to the geography and climate of Dharamshala, the building's rooftop is mostly inclined, leading to fewer available areas for installing Solar PV Systems
iv. There are a very few flat roofs available in Dharamshala so more east and west-facing buildings are needed for Solar PV Systems.

5.1.2 Risks involved in the project

i. Dharamshala receives substantial rainfall throughout the year which can physically damage the solar panels
ii. Heavy snowfall can also damage the Solar PV system
iii. During monsoons, the clear sunny days are very less so efficiency of the system will be less during that period

5.1.3 Features and Benefits to the city

i. This Solar PV system is a sustainable system that runs on solar power with no carbon emissions
ii. The maintenance cost is very low in comparison to other electricity sources
iii. Increases access to energy
iv. It is cost-saving as the Solar PV system runs on natural sources i.e., sunlight
v. This Solar PV system can be installed on a rooftop, so it does not require extra space for installation

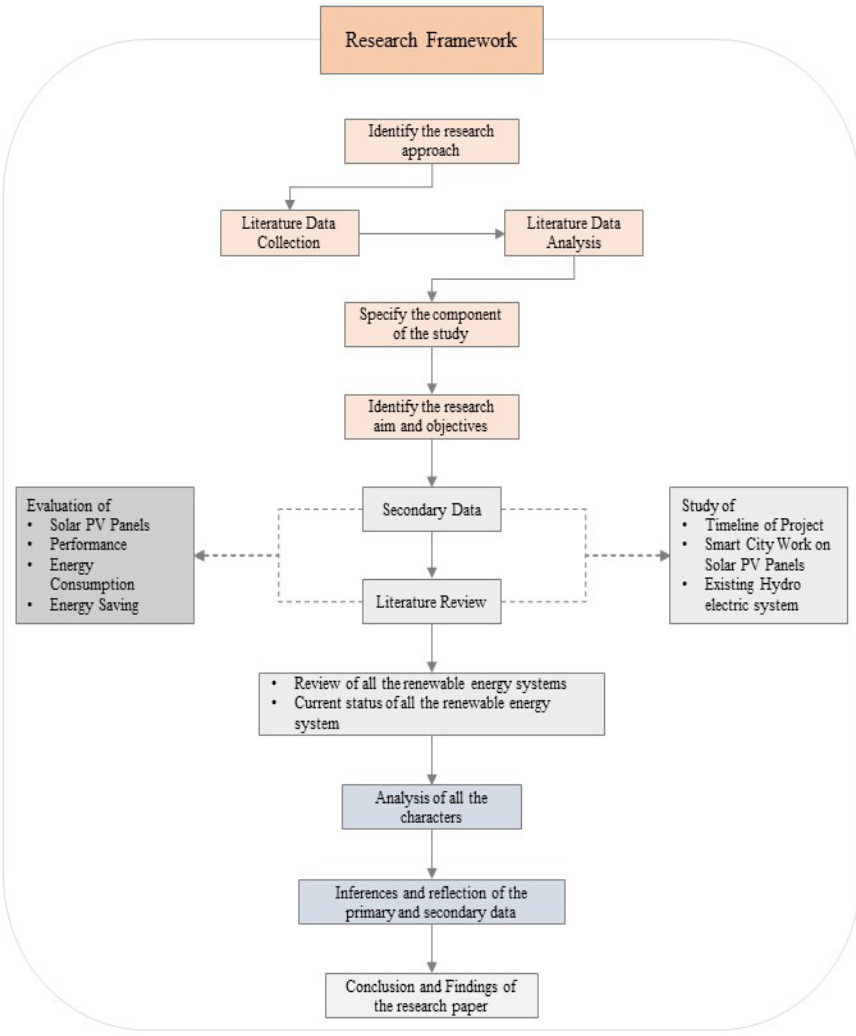
5.2 Key findings from interviews, surveys and primary/ secondary data collection

In Dharamshala, the main source of electricity is the Hydroelectric Power Plants. This renewable energy technology is beneficial to the environment since it does not produce carbon emissions or other environmental hazardous effluents. The plants are remarkably clean and efficient, generally requiring very little regular maintenance or repair. These plants have a longer shelf life and near-inflationary generating cost. In addition to preserving fossil fuels, the plants also minimise carbon emissions by substituting thermal electricity. Dharamshala is classified in the zone V of earthquake-prone areas. It is also prone to flash floods and cloud bursts which cause landslides. In 2021, Dharamshala witnessed flash floods that caused massive landslides. It is believed that climate change will worsen the conditions and the city will witness more such flash floods and cloud bursts. The flash floods cause landslides, and the debris gets mixed with rivers threatening Hydroelectric Power plants. During the recent flash floods, there was a power cut for four days in some areas of Dharamshala.

The work on two phases has been completed in Dharamshala and they are providing electricity and saving energy. The work on phase III will start soon and it will also start generating electricity from the end of 2022. Once the Rooftop Solar Mission is complete, it is expected to generate 150 MWH of electricity per month and save Rs 6 lakh per month which means that the annual saving will be Rs 72 lakh. The total project cost of all the phases was Rs 7.14 crore. In the process, Rs 72 lakh is saved in a year. In 10 years, the project may recover the installation cost. According to the officials, the lifespan of these Solar PV Systems was around 25 years. It will save Rs 18 crore if it continues to perform like now. It would also offset more than 1000 tonnes of CO_2 emissions per year which is equivalent to planting approximately 50,000 trees. During its lifespan, it will save a total of 25,000 tonnes of CO_2 emissions equivalent to the planting of 12.5 lakh trees.

Figure 13. Solar PV system installed on buildings in phase I
Source: Dharamshala Smart CitySource: Rooftop Solar detailed project report

Figure 14. Solar PV system installed on buildings in phase-II
Source: Rooftop Solar detailed project report



Solar PV Panels Methodology

S. No.	Title	Phase-I	Phase-II	Phase-III
1	Total Capacity	340.23	110.55	1000
2	Installation Cost (in crore)	2.14		5
3	Energy Output (Monthly)	150 MWH		
4	Cost Saving (Monthly)	6 lakh		
5	Cost Saving (Yearly)	72 lakh		
6	Reducing CO2 emission (Yearly)	1000 tonnes		
7	Equivalent to planting trees	50,000		
8	Payback period	10 years		

Table 6. Cost and energy saving estimation
Source: Dharamshala Smart City

6. Discussion and Conclusion

Global warming has been an increasingly prominent societal concern in recent years. According to studies, greenhouse gas emissions lead to a threatening level of global warming. Many countries and cities are turning to clean energy alternatives such as wind or solar power to provide a steady source of clean energy. Dharamshala has two renewable sources for generating electricity i.e., Hydroelectricity Power plants and Solar PV systems. Both systems have their own advantages and disadvantages. Switching to one source of electricity may not be the best option for Dharamshala, which is listed in zone V of the earthquake-prone area. A combination of both electrical systems is best for the city for achieving energy security.

6.1 Implications

The power systems for generating electricity have a serious impact on the natural environment. The goal is to reduce the impact on the environment. Hydroelectric Power systems are accepted and appreciated as a green solution. However, they have some negative externalities, especially in cities like Dharamshala, which is an earthquake-prone area and has a hilly terrain. Dharamshala is prone to natural calamities such as earthquakes, cloud bursts, landslides, flash floods, etc. So, a Hydroelectric Power system is always a threat to the city. Therefore, a safer and more reliable power system such as a Solar PV system is required which does not impact the natural environment. This system enables Dharamshala to save approximately Rs 6 lakh per month, reducing the yearly carbon emissions by 1000 tonnes, which is equivalent to planting 50,000 trees in a year (As per the approximate calculations of the Ministry of New and Renewable Energy, GoI web portal).

6.2 Limitations of the research

i. The research is limited to the work done on the Solar PV systems under the Smart City Mission in Dharamshala. The study is limited to two systems of power generating sources i.e., the Hydroelectric Power system which is a conventional power source in Dharamshala and the Solar PV system
ii. It is limited to secondary data such as research publications (major), journals, books and reliable online sources
iii. In cost calculation, the efficiency is assumed as constant throughout a lifetime
iv. Weather conditions such as rainfall and snowfall impact the energy calculation

6.3 Key lessons learnt

As solar power becomes increasingly common throughout the world, there is a greater need to implement the best solar Photo Voltaic systems and designs. It is critical to expand the common people's understanding of solar installations. The cost-effectiveness of switching to Solar PV for primary electricity generation is a serious challenge. However, Solar PV systems save money in the long run. The initial capital expenditure to install Solar PV is high. Inadequate materials and wrong installation lower the overall quality of the system, which can eventually lead to higher lifetime costs owing to greater maintenance frequency.

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B6

An Assessment of Canal Top to Set-Up Solar Power Plants in New Town (Rajarhat), Kolkata

Location: *New Town (Rajarhat), Kolkata*
Year of Project Implementation: *-2021*
Sector: *Technology in Urban Management*
SDG: *-GOAL 6: Clean Water and Sanitation*
GOAL 7: Affordable and Clean Energy
GOAL 11: Sustainable Cities and Communities
GOAL 13: Climate Action

Project Cost: *-15.95 Crores Rs.*

Institute: *Indian Institute of Engineering, Science, and Technology, Shibpur*
Advisors: *Dr. Arindam Biswas (Faculty Coordinator)*
Students: *Pranoy Kr. Mondal (student)*

Keywords: *Canal-top; Clean Development Method; Grid-responsive; Renewable energy; Solar photo-voltaic.*

Abstract:

New Town (Rajarhat), Kolkata is a Smart City, Solar City and the first Indian city to pledge for UN sustainable development goals. Use of solar photovoltaic (PV) panels on 1.7 km stretch of Bagjola canal was one of the schemes to generate minimum 5% of total energy in public facilities from renewable sources. Apart from solving the challenge of urban land-acquisition, the other advantages are reduced evaporation of canal water, longer durability PV panels due to evaporative cooling, reduced mosquito breeding and algal growth, prevention of encroachment and garbage dumping. It outweighed the extra cost of corrosion-free support structure over a canal width of 45 m – so far, the widest in India.

The grid-responsive 1MW (2x500 kW) powerplant is located near Biswa Bangla Convention Centre (BBCC) The generated electricity is evacuated to the main 33kV power-grid and is supplied to BBCC. On non-sunny times when the yield is low, the load is transferred automatically to the main grid and batteries are charged. A net meter records the generation for billing and monitoring the efficacy. Weather data is used for planning of cleaning, repair and replacement. The plant is protected from over-current and lightning.

The first phase was constructed in record six months in 15.95 Crores of Rupees (7.75% lower than the estimated budget). It is operational since May 2020 without any significant issues. The second phase got stalled due to Covid pandemic. By substituting conventional method (equivalent to 6,57,000 kg of CO_2) for the estimated annual generation capacity of 730000 units, the project can claim Clean Development Method credit. Indian canal network of about 10000 km can be explored for similar installations to supply renewable power to the neighbourhoods as well as act as host sites for urban areas where vacant land or vast waterbodies are not available.

Case Study: **B6**

1. Relevance of the Project in the Urban Context of New Town

Rajarhat New Town, a satellite township on the North-eastern fringe of the Kolkata Metropolitan Area was selected under Smart City Mission (SCM). In fulfilment of the SCM's key outcome which is to improve the 'Quality of living' (SCM, 2021) and to cater to the needs of the growing residential as well as the working population, the concerned urban and local body (ULB) of New Town Kolkata Development Authority (NKDA) conceptualised the city to be green. Accordingly, the use of a minimum of 5% of total energy in public facilities from renewable sources was planned through the National Solar Mission (NSM). Other proposals onsustainable development included: (a) semi-transparent solar photo voltaic (PV) panels with a net metering system on the rooftops in 14 public buildings and five markets; (b) Solar panels on top of a 1.7 km stretch of canal, 3.4 km long pathways on both sides; (c) Solar powered LED lights in 11 parks and playgrounds, six bus terminus/ stands, 30 auto/ moto stands, three traffic signals and 145 km of walkways.

The Ministry of New and Renewable Energy (MNRE) recognises solar energy as the most secure, abundant and reliable resource of clean energy. It is the key component of India's National Action Plan on Climate Change covering the National Solar Mission. About 26.53% of the total energy produced in the country comes from renewable sources, where solar power plays a major role. India holds 5th global position in solar power deployment. In the last 7.5 years, solar capacity has grown from 2.6GW to more than 46 GW, while its tariff has been reduced by more than 75% using plug and play model (MNRE, n.d.).

For installing solar PV panels, a vast stretch of barren land is not feasible in the urban context. Hence canal-top installation saves resources in terms of land acquisition. The added advantages are, reduced evaporation of canal water, longer durability PV panels due to evaporative cooling, reduced mosquito breeding and algal growth, prevention of encroachment, and garbage dumping. It outweighs the extra cost of support structure compared to a land-based solution. NKDA has already benefitted from one similar project at Eco Park in 2015 and a floating solar array at Smritibon water body. This prior experience helped in the conscious decision to set the current project.

2. Objective of the Project

The objective was to meet requirements set by both SCM and NSM. NKDA intends to develop an on-grid 1MW solar PV power plant over a 1.7 km stretch of Bagjola canal to generate electricity which can be evacuated to the main 33kV power grid of New Town area. The project was divided into 2 x 500 kW plants on both sides of Major Arterial Road near Biswa Bangla Convention Centre where the main consumer of the generated power resides..

3. Aspects of the Project

The aspects of the project were broadly classified under technological, data spatial / planning and stakeholders. Detailed project report prepared by CEGESS (2019) provides key information.

3.1 Technological aspect

On sunny days, the solar PV cells are designedto produce minimum 370 Watts of peak direct current (DC). Several cells in parallel when built to an adequate current, it is converted by the Power Conducting Unit (PCU) to 415 V 50 Hz 3-phase AC power and finally stepped up to 33 kV using a transformer suitable to be fed into the main grid. During insufficient solar radiation, power from PV cells is low. As the system is grid-connected or grid-responsive, it would automatically transfer the load to the main grid and charge the batteries. A net meter records the number of electric units added to the grid which helps in billing and monitoring efficacy of the energy generation of the PV array. Protection from over-current and lightning are part of it.

Solar panels show degradation over a period of time especially inhotter climates and rooftop systems. As per MNRE guidelines, the PV modules should have a useful lifespan of around 25 years with overall degradation of power generation not exceeding 20%. Being on canal-top, the benefit of evaporative cooling on longer retention of original generation capacity was expected.

Corrosion–resistant aluminium or galvanised steel structure was designed for the easy mechanical and electrical installation of the panels. As per BIS specifications, it needed to withstand a wind speed of 200 km/hour. It needed to allow installation of the PV panels facing the south and at a specified tilt angle with a modular arrangement such that replacement of a damaged panel (if any) was hassle-free.

3.2 Data

Feasibility of the project was based on solar insolation (solar energy incident on a surface) data. Using this as an input and varying the inclination of the panels, the amount of generated solar electricity was determined using the simulation software PVSyst. It is a PC-based software package for the study, sizing and data analysis of complete PV systems. For a 3degree tilt towards the south, an annual generation of 1410 MWh solar electricity with a 79.7% performance ratio was predicted.

Real-time data logging was provided for vital parameters, namely, actual energy generated, solar irradiance, wind speed and temperature. Remote monitoring and controls of these solar PV plant parameters wereto be done through software and automatically communicated to the service provider via phone, email, data transfer or IP linkage. Such action is planned for 10 years.

3.3 Planning aspect (spatial and project)

The current project was conceived by NKDA under the NSM as part of the Smart City initiative. It took inspiration from previous similar projects such as: (a) 1 MW power plant on Narmada branch canal near Chandrasan of Gujarat (2012); (b) 1 MW plant on Losari main canal of Bhimabharam, Andhra Pradesh with seasonal tilting provision of panels (2016); (c) 10 MW canal top grid connected solar power plant on Vadodara branch canal (2015); (d) 2.5-7.5 MW plants in Punjab implemented through private developers in 2017-18; (e) 1 MW plant over canals of Krishna river (2015) and (f) 500kW floating PV plant in Smritibon water-body at Eco Park of New Town.

The uniqueness of this project lies in the width of the canal which is at45m. The ideal width of a canal for installation of a solar panel array is 20-30 m. Beyond this, the support structure becomes challenging in terms of cost and structural design because it must be erected without hampering the flow and function of the canal. In this case, a truss with a 50m span supported at both ends on piles @5m C/C and connected by end trusses of 100m length. It maintained a slope of 3° towards the south.

3.4 Stakeholders

The project falls under the purview of SCM and NSM involving both the Govt. of India and the State govt. along with other stakeholders. National team

The Ministry of Housing and Urban Affairs (MoHUA) selected New Town at 23rd position out of 100 lighthouse smart cities in 2015 for promoting "core infrastructure,providing a decent quality of life to their citizens, a clean and sustainable environment and application of 'Smart' Solutions." New Town benefitted from central funding that partly coveredthe estimated project budget of 16.2 Crores Rs. and convergence with the Solar City Mission.

MNRE launched National Solar Mission (NCM) in 2010 as a key response to the country's National Action Plan on Climate Change. Its objective was to establish India as a global leader in solar energy by creating the policy conditions for the fast diffusion of solar technology across the country. A target to install 100 GW grid-connected solar power plants by the year 2022 was set. Various schemes were launched in three phases (2010-13, 2013-17, 2017-22) including canal bank - canal top scheme, bundling scheme, grid-connected solar rooftop scheme etc. Apart from financial collaboration, SCM helped in technological know-how through various guidelines, standards and research outcomes.

- **State team**

The New Town Kolkata Solar City Cell, comprising of state agencies like WBHIDCO (West Bengal Housing Infrastructure Dev. Corp.) and WBREDA (West Bengal Renewable Energy Dev. Dept. was the Steering group of the project . WBHIDCO is a public sector undertaking that plans and executes development projects in the entire Rajarhat area, while WBREDA is the state nodal agency for the implementation of non – conventional energy programmes in the state. Representatives from these two bodies were part of the team during the initial days to advise the forming of the solar city cell. Around half of the funds came from the state government.

- **City team**

NKDA was the ULB responsible for implementing the project under the SCM and key stakeholder of the project. It was constituted in 2007 for providing various civic service and amenities in the New Town area. NKDA formed the solar city cell under the West Bengal government's Green City Mission. The cell envisaged use of solar power with net metering facilities as the most potential source of renewable energy through roof-top, canal-top, floating, bus-cycle shelter and car parks. Since 2015, several solar projects summing up to 684 kW power was already in operation before the current project was taken up and NKDA appointed consultants and contractor for erection along with comprehensive operation and maintenance (O&M) through e-tender.

NKDA's effort was complemented by New Town Electric Supply Company Limited (NTESDL) as a joint venture company of WBSEDCL and WBHIDCO with equity of 50:50. Established in 2003, the organisation is responsible for 24x7 uninterrupted supply of quality power supply to the 100% population of the planned city. Underground ring main circuit for transmission and distribution lines ensured almost zero unscheduled outage. Unquestionable reliability of this main grid helped in promoting acceptability on-grid solar power supplied from the current project to Biswa Bangla Convention Centre as the requirement of the prestigious facility cannot be compromised. Smooth changeover and error-free simultaneous operation of the conventional grid and solar grid wereensured by NKDA/ NTESDL through:

i. The introduction of advanced metering infrastructure with peak load management
ii. Distribution transformer health monitoring
iii. Net metering facility

- **Academic and research institute**

Centre for Green Energy and Sensor Systems (CEGESS) of Indian Institute of Engineering Science and Technology (IIEST) Shibpur was the academic and research partner. The centre prepared the detailed project report based on the state-of-the art PV technology. They did the planning, design and vetting. For design of the supporting structure, Zeoin Infracon Project Opc Pvt. Ltd. ,an incubated company of IIEST Shibpur was involved.

- **Private firms**

Agni Power and Electronics Pvt Ltd. (n.d.) was chosen through competitive bidding as they met the selection criteria set by NKDA. It is an ISO 9001:2008 and OHSAS 18001:2007 certified company with about 25 years of experience in solar PV technology and registered channel partner of MNRE. CUTS-CRC (Consumer Unity & Trust Society- Calcutta Resource Centre) was chosen by NKDA to operate the Solar City Cell since October 2013 to assist NKDA in implementation of all projects and create awareness among all stakeholders as per the MNRE approved Master Plan (CUTS-CRC, n.d.).

- **Consumer**

Biswa Bangla Convention Centre (BBCC) managed by WBHIDCO was the sole consumer of the power generated by the current project and also connected to the conventional grid power supplied by NTESCL. It is one of the largest convention centres in South Asia with 56,932.34 sq.m. of covered area and around 5324 occupancy. Auditorium, banquet halls, exhibition spaces and a star hotel were the part of the facility which requires 1500 KVA contract demand (MoEFCC, 2017).

4. Project Implementation

4.1 Implementation/ Installation till date

The 1000 kW canal-top solar array had two units with 500kW capacity each on the Bagjola canal on both sides of the Biswa Bangla Sarani (or Major Arterial Road) connecting the convention centre and Jatragchhi flyover (Fig. 1). Starting in October 2020, the estimated duration was set as 12 months. After the bidding of the project, the cost was finalized as 15.95 Crores against the estimated budget of 16.20 Crores. Agni Power and Electronics Pvt Ltd. completed one 500 kW (5 x 100 kW) solar plant in record time of April 2021 and it was inaugurated in May 2021. By this time, construction work for the second plant was completed by 50% (Fig. 2 and 3) but the progress got stalled due to Covid-19 pandemic. Industrial oxygen necessary for cutting work was harnessed by the State Government. to meet the urgent requirement of medical oxygen (Banerjee, 2021).

The following sequence was maintained for the entire project to come up. Please refer Fig. 3 for major parts of the project.

i. Soil test to design the support structure
ii. Planning and design of the general layout of array yard, power plant and landscaping
iii. Erection of support piles and truss as per IS standard
iv. Construction of fencing, gate and security posts for the entire site
v. Laying of approach road and pathways for regular O&M activities
vi. Installation of solar panels based on the matrix design once the support structure is ready and connecting it to the grid via net meter
vii. Installation of ancillary facilities for weather monitoring and regular cleaning
viii. Inspection and testing for fault-free commissioning

4.2 Quality of implementation

The 1000 kW canal-top solar array was designed as modular one to facilitate phase-wise construction and easy maintenance. Till date, it is the widest canal

Fig.1. Google map showing locations of phase 1 and phase 2 of the solar PV plants

Fig. 2. View of the entire site showing the (a) installed 500 kW unit near Biswa Bangla Convention Centre and (b) civil work for the other 500kW unit on Bagjola canal (Source: Author)

Fig. 3. View of the panels from top (Banerjee, 2021)

Fig.4. View from the canal side road ofof the installed 500kW solar PV plant parts
Source: Author

top solar power project in the country. The 100m long plant is 45m wide compared to economic span of 20-30m commonly implemented. However, a similar 500kW solar power plant would need about 2 acres of barren land which was not feasible in metro cities. Its estimated annual production capacity is 73,0000 units of electricity, while an equivalent traditional thermal power plant would emit 6,57,000 kg of carbon dioxide (Banerjee, 2021). For this reason the project can claim the Clean Development Method (CDM) credit.

4.3 Operational and maintenance issues

The operation of the plant started with commissioning for safe and orderly operability in terms of performance, reliability, safety, and information traceability. Otherwise, it was a dangerous compromise. A commissioning checklist was used and on regular intervals, following processes werecarried out to ensure optimum performance:

- Coordination of the power plant operation to the grid within the plant and with connected sub-station as well.
- Checking and calibration of the instruments
- Detecting fault or abnormal condition if any) by crosschecking instrument parameters.
- Analyzing the generated data w.r.t. the weather data to determine the plant performance.
- Ensuring safety protocol by the personnel despite presence of automatic safety lock-out devices.

The solar PV array system was more or less maintenance-free with useful life span of 25 years except regular cleaning to prevent deposition of dust, bird dropping or dead insects. Otherwise, the sunlight didnot reach the panels hindering power generation. For this purpose, sprinklers at regular interval at 180deg jet (on both side) was arranged. A pump fed clean water (particulate matter <200 ppm) at ambient temperature and jet pressure was regulated to prevent cracking of panels. The cleaning was done during non-operational hours i.e. from dusk to dawn when panel temperature is not high followed by drying. Weather data supplied by the monitoring station helped to plan cleaning, repair and replacement schedule. It also trigerreds necessary action during high wind velocity.

Other electrical components such as transformer, circuit-breaker, isolator etc) were also part of planned maintenance which was synchronised with the sub-station maintenance. The support structure for canal-top solar plant was costlier than the one mounted on land. The metal structure was also susecptable to rusting. Hence, checking for the same, use of better paint, cathodic protection etc suitable corrosion inhibiting measures were planned.

5. Level of utilization

5.1 Authority's view

As noted earlier, one of the twin solar plants of 500kW capacity had been constructed in record time and also the total tender price was 7.75% than the estimated budget. This was a big achievement especially for public infrastructure project. However, the work for the other unit is yet to be completed. It got delayed due to Covid-19 pandemic. Except that, no other hurdle is seen to be encountered NKDA –the ULB conceiving the project tagged this successful initiative not only as part of Solar City Mission, but also included it to the list of sustainable efforts for receiving IGBC Platinum rated green city (NKGSCCL, n.d.). New Town is also the first Indian city to pledge for UN sustainable development goals (SDG 2030) by promoting usage of renewable energy (Bandyopadhyay, 2021, UN, 2021).

6. Feedback from users and other stakeholders

The entire solar power produced by the current project was supplied to Biswa Bangla Convention Centre. It was owned and operated by WBHIDCO - complementing organisation of NKDA. Hence, the data generated at the receiving end was accessible to NKDA and as well as Agni Power and Electronics Pvt Ltd. who was responsible for comprehensive O&M of the on-grid power plant. The convention centre had a contractual demand of 1500 KVA, while maximum yearly consumption was noted about 3697 MW since its operation started in 2017. The solar power plant was yet to complete its one year, but the projected annual yield based on the currently available data was 1277.5 MW. In other words, 34.55% or more than one-third of this sprawling facility was met by solar power. Being a grid connected facility, on gloomy days or at night power was drawn seamlessly from the main grid. On the quiet days, the excess power was fed into the main grid serving the city in general.

The current project was showcased as one of the top most prestigious one in their official portfolio (Agni Power and Electronics Pvt. Ltd., n.d.). After meeting the challenge of rushed schedule and exceptional width of canal, they have been successful in operating the power plant without any noted difficulty so far. In fact the same was applicable for another canal-top solar power plant project of equal capacity near Eco Park gate no. 6 which is operational since 2015.

7. Current Performance and Future Challenges

This step helped to evaluate the performance of a project to determine if objective wereachieved and if not, what corrective action were required. In this particular case, so far 34.55% of required annual power consumption at Biswa Bangla Convention Centre waexpected to be met once the second unit was completed which got stalled due to Covid-19 pandemic – a purely force majeure condition beyond the control of the project stakeholders.

The proposed 100-roomed star hotel is yet to start functioning at the convention centre - leading to more energy demand. However, if the solar city mission pledge "City ensures at least 5% of energy use at public buildings/ public space/ street lights is through renewable sources' is considered, the project is well ahead of its defined goal. In terms of other parameters, such as cost, time and quality, the current project has been successful. The bid price was tender price is 15.95 Crores compared to estimated budget of 16.20 Crores, there was early completion in April 2021 against the deadline of September 2021 and quality was also evident through error-free operation in its first year. NKDA is yet to determine the pay-back period in details considering the lifecycle cost of the current project against sum of land price saved owning to canal-top installation and cost of conventional energy saved.

As the generating capacity of solar PV cells reduces with time and higher temperature, it is essential to choose products with better specification. Also, the temperature in the city is increasing in every summer. Hence, maintaining the water flow in the canal is critical to keep the PV panels cool.

8. Inferences / Recommendations

Canal-top solar power plant projects have been successful in India in general and the current project is not an exception. NKDA's prior experience of a similar facility of 500kW since 2015 helped in fine tuning the policies of the current project. New Town is a planned city with ample open space. But the city authorities wisely realised the need of such open spaces for various public amenities and community activities such as parks, gardens, fare ground, cycle stands, open air performing areas etc rather than covering it up by solar PV panels. At the same time, Bagjola canal flowing longitudinally almost along the centreline of the New Town area has several large residential gated communities and public buildings on its banks such as Ujjivan multi-speciality hospital, Delhi Public School Newtown, Presidency University, Webel IT park. Huge demand for electricity of those buildings can be partly made by replicating similar projects on Bagjola canal.

The Kolkata metropolitan area has been benefitted in myriad ways from its canal network comprising of Bagjola canal (34 km stretch), Circular canal, Eastern canal, Tolly nala / Adi Ganga etc. Similar project can be replicated for this canal network leading to clean solar power generation, reduced evaporation of canal water, longer life of PV panels, control of mosquito and algal growth. However, many sections of these canals are choked with garbage dumping and illegal encroachment inducing urban floods. Constructing canal-top solar power plant will keep the water ways under direct control of the statutory bodies and indirectly curb these issues.

However, all such potential project may not receive funding from the Smart City Mission or Solar City Mission and therefore require private funding through PPP model. Recently, Sundaygrids – a Bangalore based company came up with innovative idea of digital solar. Where, on-grid solar panels are built at host sites (vast areas away from the city) instead of piecemeal solution of every rooftop. Individual small households can

invest for certain number of panels (called biscuits) and offsettheir energy bill at a proportionate rate. The entire process of installation, operation and maintenance is done by the company and leaves no hassles for the investors (Sundaygrids, n.d.). Such host sites can be planned for 120 major canals of India with a length of about 10,097 kilometers feeding the power to certain facilities or to the grid. Assuming, only 15-20 m width and 50% availability of this canal length, potential of canal-top solar power is 10 GW which saves 40,000 acres of land (Gupta, 2021).

Rajarhat Newtown sets high standards for renewable energy by being the first Indian city to pledge on theUN sustainable development goals. As a smart city and as well as Solar city, 2129650 sq.m. area of water body, 1423725 sq.m. of rooftop and 1997650 sq.m. open space have been identified for installing solar PV panels (Bandyopadhyay, 2021). New Town can be taken as an example of climate responsive smart city.

The Project at a glance

Name	Canal top to set-up solar power plants at Rajarahat New Town, Kolkata
Converging programs	Smart city mission and Solar city mission
Project cost	15.95 Crores Rs.
Year of completion	2021
Key stakeholders	MoHUA, MNRE, NKDA (ULB), Agni power (implementing agency), Biswa Bangla Convention Centre or BBCC (consumer)
Technical brief	2x 500 kW on-grid solar power plants built over 170m stretch of Bgajola canal near BBCC to supply clean solar energy to BBCC and excess (if any) to 33kW main power grid.
Current status	One of two of units is smoothly operational. Work on second one got halted due to Covid-19 pandemic.
Benefits	• Clean and renewable solar energy • Cost of support structure is cheaper than land acquisition in cities • Longer durability of solar panels due to evaporative cooling • Reduced evaporation loss of canal water, algal growth, mosquito breeding and controlling urban flood

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B7

Managing legacy waste

Mining of Legacy Waste and Recovery of Land at Dadu Majra Dumping Ground

Name of the project: *Mining of Legacy Waste and Recovery of Land at Dadu Majra Dumping Ground*
Location: *Chandigarh*
Year of project implementation: *2019*
Sector: *Sector 38*
Project Cost (Rs. Crore): *33.98 Cr.*
Linkages to SDGs: *Name of the Goal and Subgoal: SDG 3, 11, 12, 13, 15*

Institute: *Jamia Milia Islamia, Delhi*
Advisors: *Dr. Hina Zia, Dr. Nisar Khan*
Students: *Ripu Daman Singh, Yogesh Bharadwaj, Sachin Goel*
Keywords: *Legacy Waste, Waste Minning, The City Beautiful.*

Abbreviation: CSCL – Chandigarh Smart City Limited SCM – Smart City Mission UT – Union Territory CPCB – Central Pollution Control Board DMDG – Daddu Majra Dumping Ground DPR – Detailed Project Report, MCC- Municipal Corporation Chandigarh

Abstract:

The project titled “Mining of Legacy Waste and Recovery of Land at Dadu Majra Dumping Ground” is an ongoing project of CSCL under SCM. The purpose is to recover the 20 acres of land at DMDG, where all the waste generated within the jurisdiction of the Municipal corporation of Chandigarh is dumped daily. Overtime, the continuous dumping of waste at the site, and negligence in using resources, treating and respecting garbage generated in the process, and faulty policies have created a mound of an average height of 10m (Source – DPR of the project). Waste Deposition and continuous dumping are impacting the environment by polluting the groundwater, land, and air and impacting the physical and mental health of nearly 50,000 residents of the Daddu Majra colony. This project aims to clear the deposited waste over 20 years, so the project is named legacy waste mining. The processing facility to dispose of 0.5 million tons of legacy waste has been set up under this project in accordance with the Solid Waste Management Rules 2016 and other applicable rules and norms as amended from time to time. The project will, considering the vision of Chandigarh as “The City Beautiful”, clear the unpleasant view of landfills from the city. It will also help restore the environment by reducing groundwater, air, and land contamination improving the living conditions of the nearby residents of Daddu Majra colony. This project will institute a policy framework for other cities to deal with their dumping grounds as per CPCB’s annual report 2018-19. there are 3,159 dumpsites still operational across the country. This paper is written by analyzing the secondary data available on the internet and primary data received from the CSCL. Site visits and interviews were conducted with the personnel of CSCL, UTA, and the concessionaire of the project to enhance the understanding of the strategies, techniques, and challenges. Public surveys are used to understand the impacts of the legacy waste mining project.

Case Study: **B7**

1. Introduction

1.1 Topic and Context

Dadu Majra Dumping Ground (DMDG) is the dump yard for the city of Chandigarh spread over 45 acres of land located near sector 38, Chandigarh, and sharing its boundary with the village named Dadu Majra Colony. There is a seasonal stream known as Patali ki Rao which flows alongside the northern edge of the dumping ground. Chandigarh UT has limited land availability as the UT is landlocked between the state of Punjab and Haryana. It also exceeded its designed population, and the population is still increasing. Four hundred fifty tonnes of solid waste generated within the jurisdiction of MCC (Municipal Corporation Chandigarh), including the waste from rural habitations under the jurisdiction of UT administration, has been disposed of at Dadu Majra Dumping Ground.

DMDG was incorporated in 1985 to dump the waste of the UT. However, over the years, two huge piles of garbage developed at the site of which one was formed between 1985 to 2005, and another one is still an active dumpsite since 2005. This project is about mining the legacy waste dumped at the site up to 2005 and reclaiming the 20 acres of land covered under legacy waste.

The project was awarded to the SMS limited by CSCL. The build and operate model was selected for the execution of the project, and the project was started on 21 October 2019 with an initial timeline of 540 days. However, due to various issues, the project is still not completed, which are discussed in this report.

Chandigarh Smart City Limited (CSCL), SMS limited, and the people of Dadu Majra colony are the major stakeholders in this project. CSCL is responsible for the waste collection, transportation, processing, and disposal of municipal solid waste generated in its jurisdiction.SMS Limited is the concessionaire of this project, and the residents of Dadu Majra Colony will be directly impacted by this project as they are living very close to the site. Other stakeholders are MCC, UTA, and citizens of Chandigarh, as the waste is generated within the jurisdiction of MCC and UTA by the citizens.

The report is written by analyzing the secondary data available on the internet and primary data received from the CSCL. Site visits and interviews with CSCL, MCC, and SMS limited personnel helped further enhance our reseach. A Survey of citizens of Chandigarh assists in further understanding the outcomes and impacts of the project.

1.2 Significance of the project

Though the Dadu Majra landfill site violates the SWM rules 2016, the site was selected for landfill before the formulation of the rules. The UT has minimal land, as discussed previously, so it is impossible to find a new landfill site within the Chandigarh UT administration and MCC. ,Therefore, mining the waste from the landfill to clear the landfill site would be a better idea to incorporate the site with the SWM rules 2016 and enhance the landfill capacity.

The legacy waste that is dumped over 20 years up to 2005 forms a pile of garbage with an average height of 10m. The quantity of the waste is around 0.5 million tons as estimated by CSCL (source - DPR of the project), which is spread over 20 acres of land. This dump continuously harms the environment by polluting air, contaminating groundwater and the seasonal stream nearby, and contaminating the land. Due to the odor, groundwater, and air pollution, people of the Dadu Majra colony are prone to various diseases as they live near the landfill site. Human exposure to an odor can affect their quality of life, leading to psychological stress, insomnia, and loss of appetite. Multiple health issues includee vomiting, anxiety, stress, sleep disruption, and discomfort (source - CPCB).

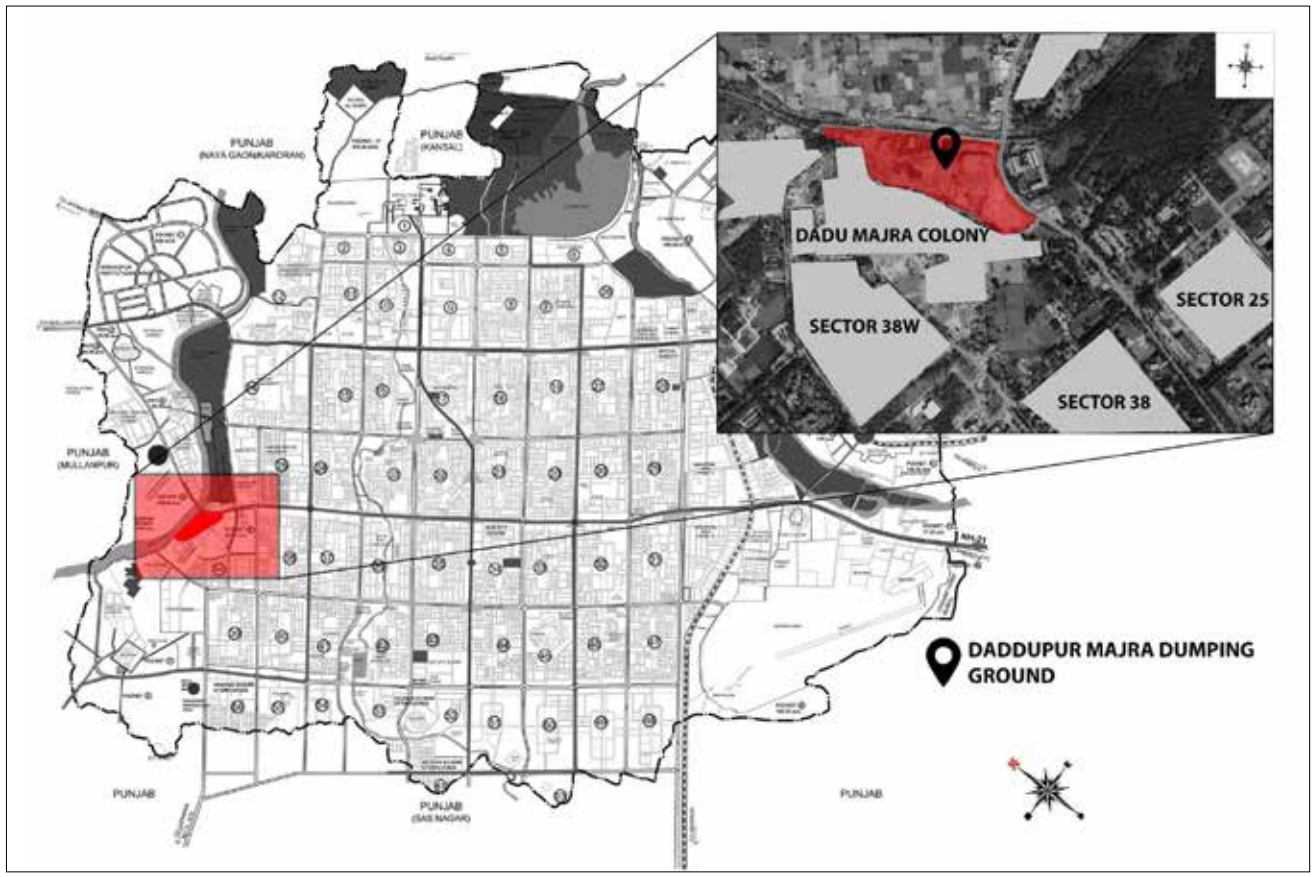

Figure 1 - Location of Dadu Majra Landfill Site
(Source: Department of Urban Planning Chandigarh Administration and Author)

Clearing the dumping ground would benefit both the environment and the community living near the dumping ground as it will eliminate the leachate problem which causes groundwater and surface water contamination. It also helps improve the air quality as the gas emissions from the legacy waste would be eliminated. By reducing the unpleasant view of the pile of garbage the project will enhance the image of the city. . It will assist in achieving its smart city vision:'The city beautiful is envisioned to become a leader in liveability, sustainability, equality, and innovation'.

1.3 Aim and Objectives

To analyze the various implications of the Dadu Majra Legacy Waste mining project.

The objectives of the study are

i. To study the impacts of the project on the surrounding environment.
ii. To study the project's impacts on the nearby settlements and the city.
iii. To study the various strategies and techniques used in the execution of the project.
iv. To identify the various issues and challenges faced by the administration and the vendors involved in the project while executing.
v. To appreciate the innovation done in the project.

2. Contextual Background

Dadu Majra Dumping Ground is innovatively divided into three parts. The irst one is the legacy waste, deposited up to 2005, including 8.1 hectares of land. Second is the active dumpsite on which the waste of the city has been continuously dumped since 2005, which covers an area of 3.25 hectares, and the third is the proposed SLF (sanitary landfill) which is still under construction and comprises of 3 hectares of land as shown in figure 2. The division of the site into three parts ensures the functionality of three different functions (mining, dumping, and construction of new SLF) at the same time on the same site without any interruption.

Component	Legacy waste dump
Area of dump	20 acres = (20x4048) = 80960 sqm
The average height of the dump	9.50 meters (31 feet)
Volume	80960x9.50=769120 cubic meters
The density of the compacted legacy waste	(as per chemical analysis) 637 kilogram per cubic meter
Weight of legacy waste	Volume x density = 769120 x 637 = 489929440 kg
Approx. 489929 tonnes (say 5 lacs tonnes)	

Table I Shows the calculations regarding the quantity of legacy waste
(Source - DPR of the project)

Table IV shows the proportion of different kinds of materials in the legacy waste, which highlights that the organic waste comprises the maximum percentage—this can be used as compostagriculture and green areas or parks of the city. The second largest part is the inert materials that can be used in construction. The third largest part is combustible waste which can be utilized as the RDF in waste to energy plants and cement factories. The fourth part consists of non-biodegradable waste that can be recycled after extraction from legacy waste.

Figure 3 shows that Dadu Majra Landfill violates the Solid Waste Management Rules 2016 which says that the landfill site should be 100m away from any navigable river or stream and 500m away from any habitation area. The legacy waste at Dadu Majra is only 30 - 35m away from the seasonal stream Patali ki Rao, around 25 - 30m away from the residential colony known as Dadu Majra colony.

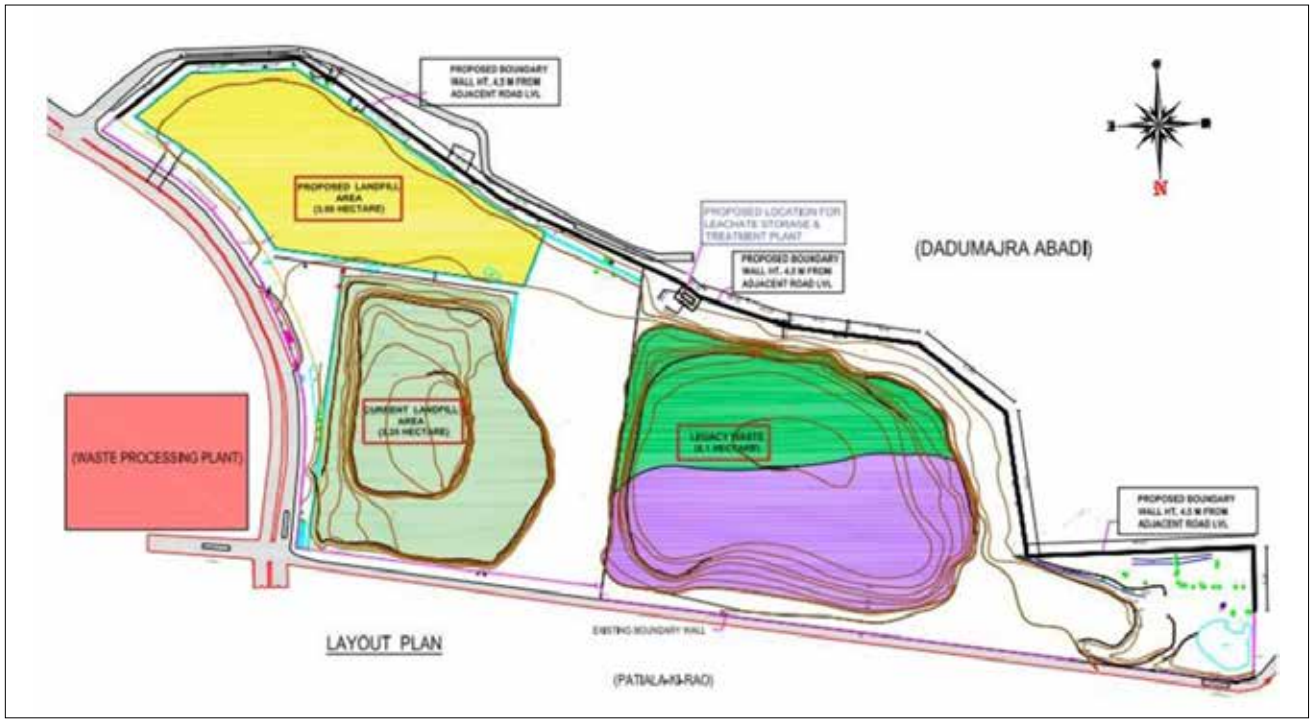

Figure 2 - Dadu Majra Dumping Ground Site Plan
(Source - Chandigarh Smart City Limited)

S. No.	Particulars	Results (%)	Density (Kg/ Cubic Metre)	Weighted Density (Kg/cubic metre)
1	Organic Waste			
	a) Garden & Park Waste, Non food organic biodegradable material, Food Waste	30.50%	1029	313.845
2	Combustible Waste			
	a) Paper	4.40%	228	10.032
	b) Cardboard	0%	55	0
	c) Textile + Jute Bags	3.30%	240	7.92
	d) Wood and Straw waste	12.30%	156	19.188
	e) Leather	0.96%	450	4.32
	f) Rubber/tyre	1.60%	400	6.4
	g) Non PVC Plastic & others packing material	8.20%	72	5.904
3	Non-Biodegradable Waste			
	a) PVC Plastic	4.90%	72	3.528
	b) Metal	0.30%	120	0.36
	c) Glass/China clay material	1.30%	411	5.343
4	Soil/Sand/Clay/ Inert Material	29.40%	830	244.02
5	Miscellaneous			
	a) Battery, Electronic Waste, Soiled Material or any unidentified Material	2%	810	16.2
Weighted Average Specific Gravity of Dumped Waste				637.06

Table II Showing composition and weighted average specific gravity of waste dumped
(Source- DPR of the project)

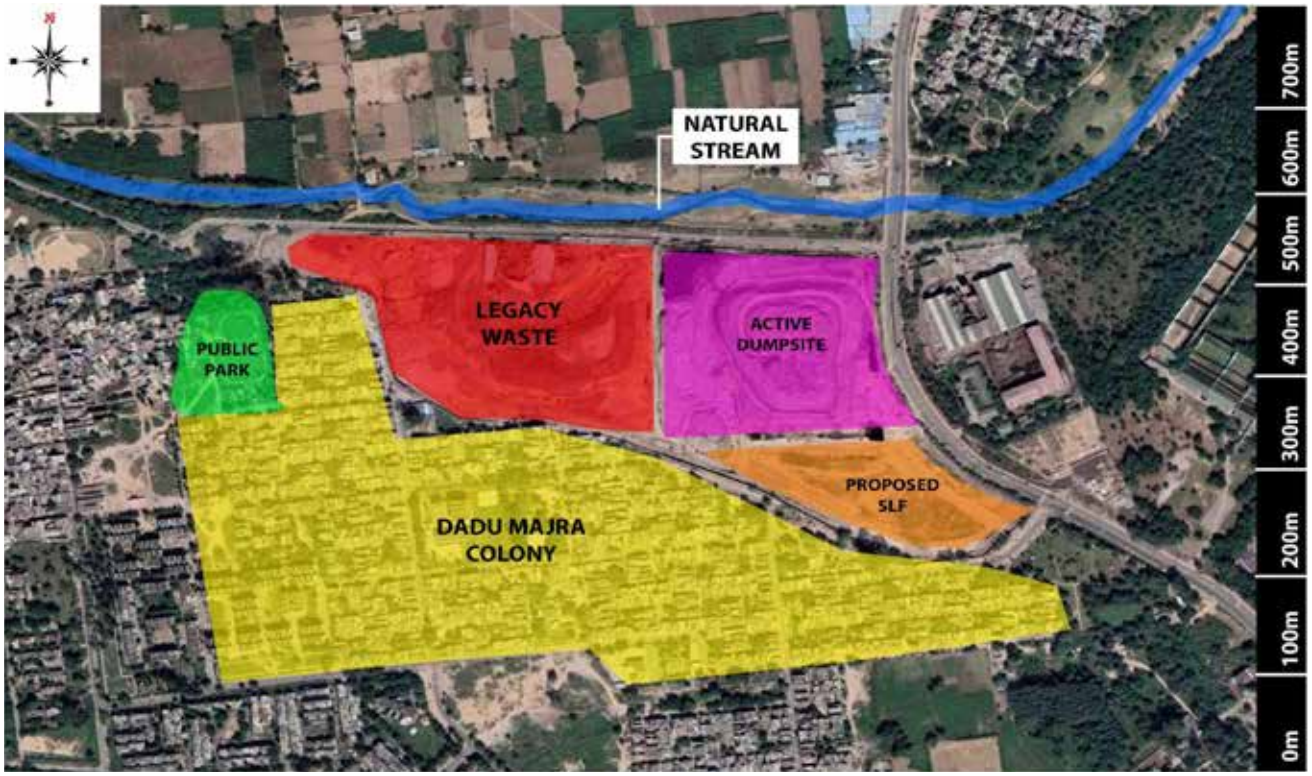

Figure 3 - Showing the surroundings and parts of Dadu Majra Dumping Ground
(Source - Google Earth and Author)

Figure 4 - Image of active dumpsite
(Source - Author)

Figure 5 - Graphic representation of the concept of biomining
(Source - DPR of the project)

S. no.	Place	Minimum Siting Distance
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas, and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 meters (m) away from the flood plain
3	Pond, lakes, water bodies	200m
4	Non-meandering water channel (canal, drainage, etc.) 30 m	30m
5	Highway or railway line, water supply wells	500 m from centerline
6	Habitation	500m
7	Earthquake zone	500 m from fault line fracture*
8	Water table (highest level)	The bottom liner of the landfill should be above 2 m from the highest water table 9
9	Airport 20	20 km

Table III Showing the criteria for selection of Landfill site
(Source - Municipal Solid Waste Management Manual)

Biomining of the legacy waste includes the excavation, screening, and material recovery, as shown in figure 5. In biomining, the first step is the excavation of the waste through the excavators, and then it is left in the sun and air for removal of moisture and odor so that its screening becomes easy. After the removal of moisture and odor, the screening process starts which is done manually on the site for which SMS Limited has hired ragpickers which separate the combustible materials from the waste in the form of RDF which sent to the waste to energy plants or cement factories then the remaining waste is sent for the material recovery in which the waste is passed through different size of trommels which segregate the inert materials from the waste which is sent to the construction sites for earth filling at the same time the metal is also recovered from the waste with the help of the magnet which is sent to the recycling industries the final product of the waste after material recovery is the bio soil which is used as the compost in the agricultural fields and green areas or parks of the city. The process of biomining is shown in figure 5.

2.1 Conceptual framework / Research design

This research is divided into four stages. The primary stage starts with the secondary data collection available on the internet and preparing an initial report by analyzing the secondary data. Request for proposal of the project and solid waste management report of Chandigarh are the major sources in the initial reports in which the information gaps were identified.

The second stage comprises collecting the primary data from Chandigarh Smart City Limited in which the detailed project report and a detailed preliminary report is the major source of information that is incorporated with the initial report, and the report was further updated by filling the initial information gaps and updating the previous information as per the requirement is done including identification of the stakeholders. After completing the second stage report, other information gaps were identified, and a questionnaire was prepared according to the information gaps.

The third stage consists of the site visits and interviews of the Chandigarh Smart City Limited personnel, UT administration, and the Municipal Corporation of Chandigarh, and SMS limited (concessionaire of the project). This is the most crucial stage of the research as it provides a lot of information regarding the project and enhances the understanding of various aspects of the project. People-survey is also carried out in this stage which further enhances the understanding of the impacts of the project on the citizens regarding waste. The figures below show the images of the site visit, discussions with administrative bodies, and public opinion regarding legacy waste mining and Dadu Majra dumping ground.

The final, , fourth stage, is preparing the final report by incorporating all the information received through the interviews regarding innovations, challenges, and implications of the project. Site visits and interviews help extract mostly all the information identified as gaps in the second stage. A public survey helps better understand the project's implications and conclude the report.

2.2 Key features of the project

i. Dividing the site into three parts to ensure the independent functioning of legacy waste mining, dumping of waste on an active dumpsite, and construction of a new SLF.
ii. CSCL utilized an innovative approach in the contract agreement, which says that the concessionaire shall bear any cost increment due to the delay in the project to ensure the project is executed at a fixed cost and it also makes the concessionaire more responsible in utilizing their time, money and energy efficiently.
iii. The revenue generated from selling the material recovered by the mining belongs to the concessionaire, which ensures the project's cost-effectiveness and reduces the chance of corruption in the process.
iv. Maximum utilization of the land resource: The vendor involved in the project does not take extra land to establish their processing plant (trommels, office, required infrastructure, and space for storing RDF, inert material, and bio soil). They cleared 2 - 3 acres of land by shifting the waste and increasing the height of pile to establish their processing plant and temporary office.
v. Incorporating the ragpickers in the biomining process provides employment to the ragpickers.
vi. Monitoring the progress of the project on a monthly basis ensures the proper operation of the project.
vii. The processing plant operates for 20 hours daily, enhancing the daily capacity of mining waste. The plant processes 15 tonnes of waste per hour, but the designed capacity of the processing plant is 25 tonnes per hour. The processing is not done at its full capacity due to moisture in the excavated waste, and the waste should be in a dehydrated state before sending it to the processing plant.

2.2.1 Challenges in the project

i. Establishment of waste processing plant: , The concessionaire, had to set up their plant within the limits of 20 acres of land over the landfill, which was entirely covered by the waste with an average height of 10m. The Concessionaire cleared around 2-3 acres of land to establish their trommels and other infrastructure required for mining the waste by shifting the waste and increasing the height of the pile.
ii. Finding the buyers of RDF (Refuse Derived Fuel): RDF is the refuse-derived fuel that comprises around 14% of the total material that is recovered from the legacy waste and used in cement factories or waste to energy plants. Very few buyers are available for the RDF excavated from the waste (source: SMS limited, concessionaire of the legacy waste mining project).
iii. Monsoon: Chandigarh falls under Koeppen's CWG category i.e. it has cold dry winter, hot summer, and subtropical monsoon. Southwest monsoons with high-intensity showers commence in late June. The weather at this time is hot and humid. The variation in annual rainfall on a year-to-year basis is appreciable i.e. 700 mm to 1200mm, and the 20-year average rainfall for Chandigarh is 1100.7 mm. In the mining of the waste, the waste must be dry before segregating RDF and sending it to the trommels, wet waste cannot be segregated and sent to the trommels.
iv. Covid 19 pandemic (resulting in the delay of the project) could also impact the overall cost of the project.

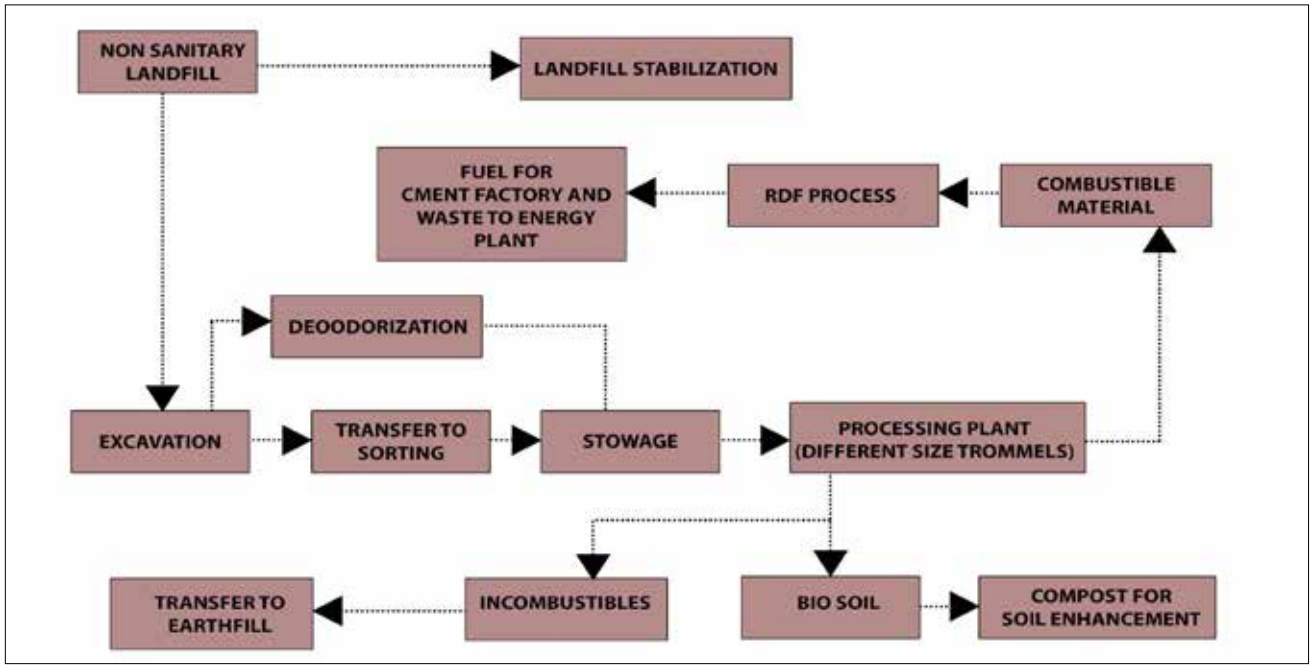

Figure 6 - Detailed Process Flow Diagram
(Source - DPR of the Project)

Figure 7 - Images of DMDG Site Visit (Left) and Meeting at CSCL Office (Right)

2.2.2 Risks involved in the project

i. Storage of RDF (Refuse Derived Fuel): RDF comprises 14% of the total material mined from legacy waste. The volume of this RDF is huge as compared to its mass. Due to a lack of buyers, the RDF obtained from the legacy waste on a daily basis is deposited on the site in a considerable amount. It occupies a huge chunk of land, which can be an obstacle to the functioning of the plant, but no such incidence is recorded so far.
ii. Unseasonal Rain: some rain falls in January and February as well. Waste should be completely dry before sending it to the processing plants (Trommels). A single rain can affect the processing of the plant for one week.
iii. Issues related to funds: If any kind of delay in the project due to natural causes like a pandemic, unseasonal rain, or too much increment in the cost of fuel that surpasses the initially decided budget could result in complete failure of the project as no vendor will not be able to bear the losses.
iv. Hazard to the workers at the site: Working on a landfill site can impact workers' health due to high levels of pollution and dust, but the chances are low as the workers are not exposed to the raw waste after excavation. Their direct contact with the waste is only after removing complete moisture and gasses.

Figure 8 - Images of the processing plant and excavation of legacy waste mining (Source - Author)

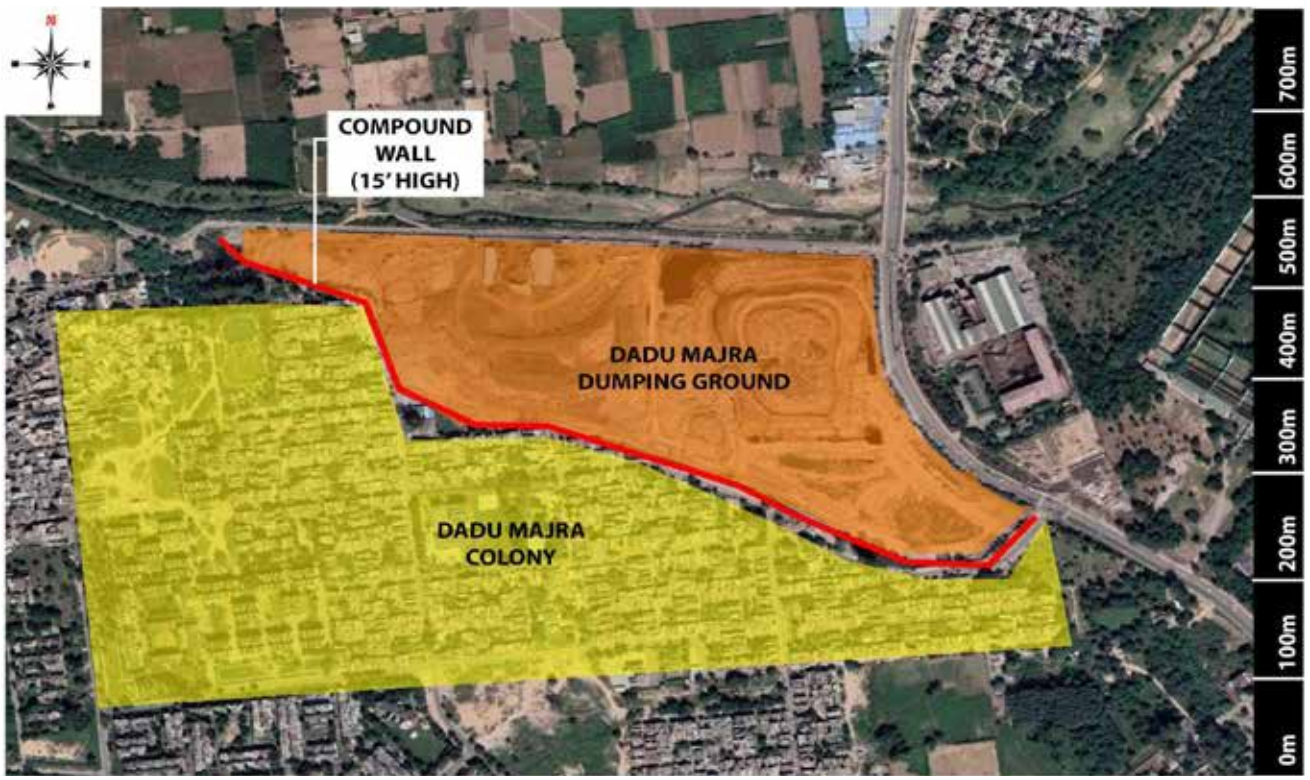

Figure 9 - Showing compound wall on map (Source- Author)

2.2.3 Features and Benefits:

i. Administrative efficiency and effectiveness: Unique feature of this project lies in its contract agreement that the project's increased cost due to any delay in completing the project shall be borne by the concessionaire.
ii. Social Impacts: Residences of Dadu Majra colony will directly benefit from the mining of the legacy waste. They have to face social embarrassment, various health issues (like cancer, breathing problems, and high blood pressure) due to odor, unpleasant view of mountains of garbage, gas emissions from landfill,s and groundwater contamination due to the landfill in their proximity. This mining will also improve the city as the mountain of garbage provides an unpleasant view and deteriorates the image of the city.
iii. Environmental Impacts: Mining the legacy waste would stop the groundwater contamination (as there will be no more leachate after clearing the waste). It will also help improve air quality by terminating the gas emissions from the waste, and the land pollution will also be reduced, which will help improve biodiversity. In the study, it is found that the legacy waste is violating the CPCB guidelines for the landfill as the landfill is located near the natural water stream (minimum 100m distance), the same violation will be terminated with this project.
iv. Economic impacts: The project cost is around Rupees 34 crores which recovers the expensive land of around 20 acres in the city after completion of the project. It will also increase the land value in the nearby Dadu Majra settlement as the people will be more interested in buying the land in Dadu Majra colony.

2.3 Key findings from the interviews, surveys, and primary/secondary data collection

i. Limited social and environmental impacts: The project only covers the clearance of waste dumped over the site till 2005. But there is another existing pile of garbage having a maximum height of around 25m on the same site beside the legacy waste, which has been an active dumpsite since 2005. The active dumpsite is at a distance of 60m from the river Patali ki Rao and around 150m to 250m from Dadu Majra Colony. (See figure 4 and 5)
ii. Development of new SLF: New SLF (Sanitary Landfill) is under construction on the same site, which is the project of CSCL. New SLF is more than 250m away from the natural water stream but very close to Dadu Majra colony (the distance is less than 100m). New SLF is not as per the SWM rules 2016 (which specify that the sanitary landfill should be 500m away from any habitation).
iii. Initiatives to reduce the burden on Sanitary landfills : New solid waste management policy of the city by CSCL is quite promising in terms of waste collection and its processing.
iv. Solid Waste Management by CSCL: CSCL incorporated new waste collecting vehicles. The vehicles have separate compartments for dry and wet waste. For wet waste there is a composting plant

near DMDG with a capacity of around 80 tonnes per day. For dry waste 3 material recovery facilities are established in the city under construction. When they start functioning, the pressure on the landfills will be reduced substantially.

v. Ensuring 100% waste collection with proper segregation: CSCL employs an innovative way to ensure 100% waste collection with proper segregation by introducing the helpline system. The system allows people to complain about their waste collector if the collector is not coming to their area, and waste collector can also complain about the houses which are not giving their waste or giving their waste without segregation. There is also a plan for imposing a fine on not segregating the waste.
vi. Incorporating solid waste management with the ICCC : Provision of SCADAs regarding tracking the waste collecting.
vii. Employment to the ragpickers: Incorporating the ragpickers in the waste collection process.
viii. Ensuring the funding for solid waste management in the city: Introducing the solid waste bill and incorporating the solid waste bill with the water bill is an innovative approach to ensure the funding of solid waste management in the city.

- People-centric approach to reduce social impacts of landfill: 15 feet high compound wall at the edge of dumping ground facing Dadu majra colony to hide the unpleasant view, reduce the odor in the habitation area due to landfill, and ensure the termination of illegal entry of rag pickers and animals for their safety as shown in figure 9 and 10.
- Citizen survey regarding the legacy waste mining project and Dadu Majra Dumping Ground: in a public survey of 38 people in which they could select multiple options 52.6% people said that it would improve the health and hygienic conditions, 68.4% people supported that it would be helpful in improving the environment, 36.8% were in support with the statement that it would remove the unpleasant view of the waste, 21.1% sees no impact of this project while only 2.6% were in support of completely shifting of the Dumping Ground from Dadu Majra and 2.6% says that it smells terrible near the Dadu Majra Dumping Ground.

3. Conclusion

From the study of the legacy waste mining project, it is concluded that legacy waste mining would benefit the city and nearby areas by improving their social, economic, and environmental conditions. Furthermore, the innovative approaches of the administration and concessionaire in formulating the strategies and execution of the project should be incorporated by the other cities as well while dealing with their landfill sites.

However, the Dadu Majra landfill site is not only limited to its legacy waste. The site has another huge garbage pile, and a new proposed SLF. The legacy waste mining project will only partially improve the various socio-environmental conditions. A new solid waste management policy for the city by CSCL would be a positive approach to reducing the pressure on the landfill, which can become the foundation stone in making the city a zero-waste city.

3.1 Implications

In our view, the project will lead to the following implications:

i. Social up-gradation of the residences of Dadu Majra Colony.
ii. Environmental up-gradation of the surrounding areas and the city.
iii. Termination of further groundwater contamination due to legacy waste.
iv. There will be a decline in diseases arising due to landfills.
v. 20 acres of the recovered land will be the return value of Rs. 34 crores investment.
vi. Fire incidences in the landfill will be eliminated.
vii. Reduction in the amount of leachate generated due to the landfill contaminating the groundwater.
viii. Seasonal stream Patali ki Rao would no longer be polluted by the legacy waste.
ix. Help in mitigating the causes of climate change.
x. A sustainable way to manage the city's waste and an initiative toward a circular economy.

3.2 Limitations of the research

This report only focuses on the legacy waste mining project at DMDG, but the dumping ground is divided into three parts in which only one part is studied in this report which is not sufficient to analyze the complete site, and solid waste management of the city is also directly linked with the dumping ground which is also not covered in this report. However, after visiting the site and interviews with the representatives of CSCL, we can put light on all the aspects related to the Dadumajra Landfill site and incorporate all the factors in concluding the report.

Due to time and resource constraint, a more extensive public survey including the opinion of people living in the Dadu Majra colony is not carried out. However, their opinion is taken from various news articles.

3.3 Key lessons learned

This research resulted in several learnings for us—some key ones are stated below:

i. Understood the importance of the Landfill site in the city.
ii. Finding a new landfill site for a city is a very difficult task.
iii. Managing the dumping ground for a long time is possible by making it efficient to clear the old waste while continuously dealing with the daily waste at the same time and making it ready for future waste disposal.
iv. How to resolve the issues related to landfill sites with maximum utilization of existing resources and innovative approaches.
v. How to increase the efficiency of solid waste management in the city.
vi. What are sustainable ways of utilizing waste and the way towards a circular economy?

3.4 Recommendations

i. There should be plans to utilize the land that will be recovered after mining the legacy waste.

Figure 10 - Image showing the construction of the compound wall (Source: CSCL)

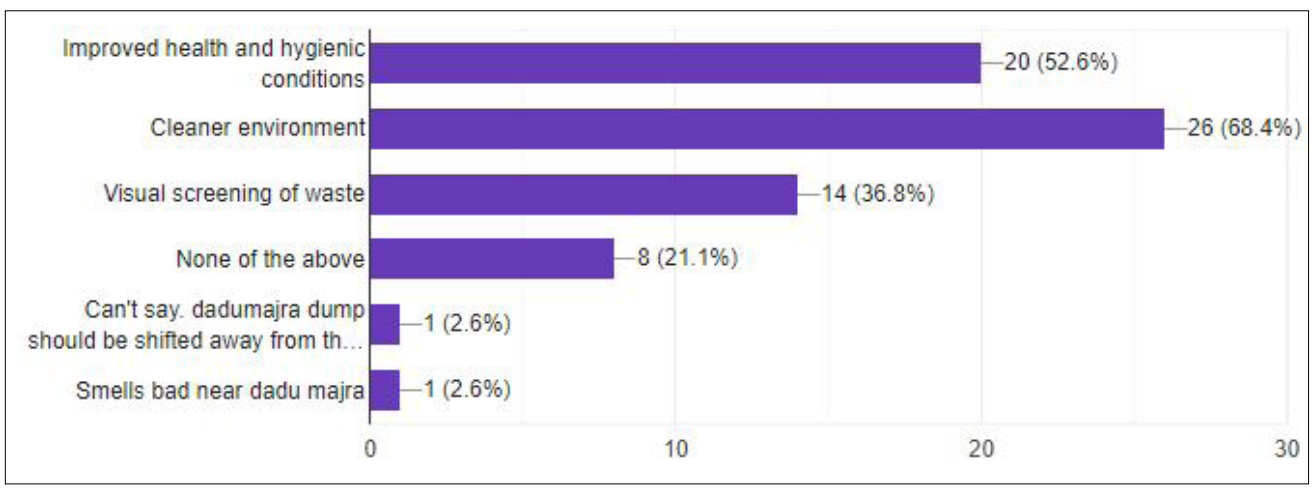

Figure 11 - Graphical representation of public opinion about the project and DMDG (Source - Opinion of 38 citizens)

ii. CSCL/MCC should execute another planned project to clear the waste pile beside the legacy waste, which is still active.
iii. As the legacy waste mining project is near completion, the already established processing plant, including trommels and other machinery with existing infrastructure, could be utilized rather than installing a new plant, it will save time and energy in clearing the ground for establishing a new plant.
iv. Administration at the central or state level should formulate the policy to create the demand for RDF (Refuse Derived Fuel) and inert that is mined from the landfill sites.
v. New SLF that is under construction at DMDG is violating the SWM rules 2016, and the city administration should find a new site for SLF.
vi. The city administration should formulate the policy to formally incorporate ragpickers into waste management by providing them with proper training and safety equipment.

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B8

Redevelopment of AnnaSagar Lake: Ajmer

Name of the project: *Redevelopment of Anasagar Lake*
Location: *Ajmer, Rajasthan*
Year of project implementation: *2019*
Year of project completion: *2021*
Project Cost: *Rs 40.19 crore*
Linkages to SDGs: *SDGs 3.9, 3.10, 6.3, 11.3, 11.4, 11.7, 16.5, 16.6, etc. (Annexure 4)*

Institute: *Malaviya National Institute of Technology, Jaipur*
Advisors: *Dr. Nand Kumar, Dr. Niruti Gupta, Dr. Pooja Nigam, Dr. Bhavna Shrivastava, Sangeeth S Pillai*
Students: *Prerna Jasuja, Arya Malayali P, Kshitiz Agarwal, Vivek Ahirwar, Shreshtha Sachdeva, Diksha Bankar, Rhitwik Gupta, Maitreyi Sapre, Srishti Singh, Gaurav Panchal, Aman Ahuja, Sanyam Narang, Jayant Sharma, Amil Kumar, Ronak Parmar, Prisha Singh, Shubham Kuri*

Keywords: *Quality of life, Recreational space, Lakefront development, Bird Park, Pathways, Urban Haat*

Abstract:

Ajmer is the 7th largest city in the state of Rajasthan and is known for its rich heritage. Over the years development activities have left the city with lack of recreational spaces which has been described in the Ajmer Master Plan 2033. The project Redevelopment of Anasagar Lake was initiated to provide a sustainable solution to these issues that the city currently faced. The aim was to make use of the underutilised natural resources and physical features of the city which include Anasagar Lake and its surroundings and to create multi-functional areas to serve the people of Ajmer. The project included construction of pathways around the lake, protection of the Bird Parks and building an Urban Haat. The project aimed to provide functional spaces for recreation, healthy lifestyle along with contribution to the tourist potential of the city. The Bird Parks can be seen preserving the natural habitat for the birds of the area and essentially furnish an opportunity for the people to enjoy the same and learn to co-exist. The report has been compiled from details collected by interviewing the experts of the Smart City Project. Subjective opinions were collected through primary surveys conducted on the public and other stakeholders, and through observational surveys. It was observed that the initiative, though certain areas are still under construction, has been well received by the local residents of Ajmer and is changing the face of the city for tourists. Although some shortcomings are present in certain areas like construction, operation and maintenance, the overall success rate of the project can be noted as high from the studies made.

Case Study: **B8**

1. Introduction

Ajmer is one of the 100 cities taken under the Smart City Mission. The Ministry of Housing and Urban Affairs (MoHUA) is responsible for implementing the mission in collaboration with the state governments of the respective cities. Recreational spaces serve complex functions in a city. They can enhance the visual appeal to improve the overall community living aspects of a city. For sustainable development, adequate recreational spaces need to be allocated. (RFPs provided for Development of Pathway around Anasagar Lake)

From the Mughal period the Anasagar Lake stands as a living element of the historical era. It is spread over 13-km. It is the largest lake in Ajmer with a catchment of 5-sq km built-up area having a capacity of 4.75 million cubic meters. (Pratyush 2021). The Lake has huge possibilities while supporting a rich aquatic life and a wide variety of annual migratory birds. It is estimated that there are more than 50 species of birds at the Anasagar wetland, and it is the maximum in the winter season. The lake area can be moulded into a well-developed recreational space and become a recreational area of the city. The process can eventually improve the city's image and increase the community interaction spaces. It has been well-established that biodiversity plays an irreplaceable role in ensuring the quality of human life through supporting ecosystem functions and services. Spatial patterning of patches of urban vegetation holds the key to providing relatively suitable conditions for urban wildlife to remain in the cities and support the ecosystem services despite ongoing pressures on wildlife habitats imposed by urban development and climate change (Rastandeh et.al 2017).

Development of pathways along the lake is important to allow users to access the lake site for leisure, enjoying the view and for activities such as photography, walking, jogging, exercising and taking pets for a walk, etc. (RFPs provided for Development of Pathway around Anasagar Lake)

Figure-1: Projects' Location around Anasagar Lake

'Urban Haat', as the name indicates, is a permanent marketplace for crafts, food and cultural events that brings artisans and customers together at one location (Gupta ***et.al*** 2021). The food court within the Urban Haat complex serves a variety of foods. Consumers come to the Haat expecting the following:

a. High variety and quality of products
b. Lower prices
c. Good layout and environment
d. Cleanliness and security
e. Helpful and courteous staff
f. Visual stall appeal and replying to queries
g. Effective promotion of the event (Attri 2018)

In terms of infrastructure, facilities, maintenance, stall allocation, resource generation, fund allocation, and monitoring the government has developed a framework for setting up sustained performance of Haats at the village, district and state levels. (Ministry of Textiles 2006)

1.1 Topic and Context

The Smart City Mission at Ajmer proposed to develop the area around Anasagar Lake for its improvement, beautification and overall development. The redevelopment project includes the development of pathways along with the lake, bird parks, food courts, etc.

1.2 Significance of the project

Ajmer, with a population of 5.43 lakh (Census, 2011), has several natural and man-made features. The city attracts tourists from within the state as well as from other states. According to the Master Plan 2033 for Ajmer, the deficiency in the city is described in terms of public open spaces and recreational spaces along with degraded water quality at the Anasagar Lake. The project paves a way to resolve the issues and to improve the overall image of the city while improving the quality of life (Govt of Rajasthan, 2013).

Presently, the Anasagar Lake is cleaner than it was earlier due to various initiatives undertaken by the government and has a large number of visitors (Jasuja P). The focus of the redevelopment project was to evolve the spaces into one that is economically viable and help in improving the image of the city and benefit the citizens. Thus, the old resting place has been converted into a recreational space by making it a wetland for migratory birds and development of a park around it for the citizens.

Anasagar Lake has a diverse aquatic life along with many migratory birds that visit the lake each year. A large plot of land is available as a wetland near the lake behind the Sagar Vihar Colony in Vaishali Nagar as shown in Figure-1 (Sagar Vihar Bird Park). This land is undeveloped, but it is home to many local and migratory birds.

The wetland provides a safe refuge for birds for food, shelter and nesting. The area also attracts many morning walkers, tourists and bird watchers/photographers.

The idea of proposing an Urban Haat was to provide a recreational space for serving multi-cuisine food and beverages within one single compound. It also promotes the economic activity around the existing Jila Udyog Sangh's Exhibition Center while providing a robust social space for the public.

The total cost of all the projects is:

Project Name	Project Cost (Rs crore)
Pathway-1: Shiv Mandir to Sagar Vihar Pal	5.42
Pathway-2: Sagar Vihar Pal to Regional College	13.10
Pathway-3: Old Vishram Sthali to Rishi Udyaan	13.61
Urban Haat	1.43
Old Vishram Sthali Bird Park	5.46
Sagar Vihar Pal Bird Park	1.17
Total project cost	40.19

1.3 Aim and objectives

The aim of the project was to develop a green belt after cleaning the lake and to make a proper space for migratory birds without much disturbance to their natural habitat. It also aims to find the project's impact on the ecological development of the city and the development of a prominent recreational space.

Objectives:

a. To provide a Pathway along the periphery of Anasagar Lake for the residents as well as visitors. The aim is to encourage physical activity and boost social interaction
b. To increase access for the citizens to open spaces and recreational areas that are safe and promote physical activity
c. To improve the aesthetic look of the Anasagar Lakefront for better environment quality while preserving the local culture and heritage
d. To create a wetland area with suitable fauna and provide a safe nesting place for birds

e. To provide attractive, usable and accessible spaces to the public with special emphasis on children-friendly and elderly-friendly

2. Contextual Background

2.1 Conceptual Framework/Research Design

To evaluate the project, the survey team conducted interviews with experts from the Ajmer Smart City Office, understanding the need, objectives and significance of the projects. A primary survey was then conducted to assess the current scenario and to identify gaps in the facilities proposed, if any. For primary survey, the public visiting the respective areas became the sample base. The next step was to analyse the collected survey data to identify the gaps between the expected outcome of each project and the existing scenario.

The methodology adopted for the research:

.a. Lakefront Development of Bird Park at Old Vishram Sthali, Anasagar:

The proposal was to develop Vishram Sthali as a Bird Park and the scope of work included creating more ponds by retaining adequate water for the wetland area, planting suitable species of trees and shrubs as required, providing shelter, protection and food for the birds. There was also a proposal for a watchtower facility that will enable bird watching and help photographers and tourists. Along with this, the development of parking areas, pathways and cycle tracks was adopted for the convenience of the people. Food court, sitting spaces, garden furniture and signboards will also be provided.

It is necessary to provide a safe place for migratory and local birds and develop the tourism potential of the area. Good quality urban green spaces can generate economic value by itself. According to Amber et. al (2010), parks give opportunities that encourage people to gather together and experience social support.

b. Sagar Vihar Bird Park, Anasagar:

The proposals were carried out in two segments of wetland that exists behind Sagar Vihar Colony - Part–A and Part–B, which are 26,400 sq m and 11,000 sq m, respectively. Both areas have seepage and drainage water ponds and attract water birds. Wetlands were created for the natural habitat.

The wetland must have adequate water at all times, so it was proposed to dig a tubewell and create more pond area. Planting suitable species of trees and shrubs and tree guards as required was also offered to provide shelter, protection and food to the birds.

c. Development of Pathway around Anasagar Lake:

- From Shiv Mandir to Sagar Vihar Pal (Completed): Pathway-1 (960m)
- From Sagar Vihar Pal to Regional College (Completed): Pathway-2 (1834m)
- From Vishram Sthali to Rishi Udyaan (Under Construction): Pathway-3 (2332m)

The construction work of Pathway-1 (960m) from Shiv Mandir to Sagar Vihar Pal on the bank of Anasagar Lake in Ajmer has been completed. The work started on 20 November 2020 and was completed by 19 November 2021. The construction of Pathway-2 (1834m), from Sagar Vihar Pal to Regional College has almost been completed. The work started on 18 December 2020 and was completed by 1 December 2021. The construction of Pathway-3 (2332m), from Old Vishram Sthali to Rishi Udyaan started on 4 November 2021 and is still under construction.

Pathway	Length of the Pathway (m)	Project Cost (Rs crore)
Shiv Mandir to Sagar Vihar Pal	960	5.42
Sagar Vihar Pal to Regional College	1834	13.10
Old Vishram Sthali to Rishi Udyaan	2332	13.61

The width of the pathways is 3.60 meters. They have white sandstone anti-slip flooring (40mm thick) and are both child and elderly-friendly. Pathway-1 has been equipped with iron railings and street furniture made of sandstone for protection purposes. The other side of the pathway is provided with a sitting area made of white sandstone (750mm high). The sitting area consists of street lights at regular intervals. No signages are provided on any of the two pathways. For further protection, on the lakeside, RCC retaining wall needs to be constructed, and on the other side stone masonry toe wall. A parapet/railing needs to be built on the entire length of Pathway-2. Currently only a specific part of Pathway-2 has railings.

Waste accumulated in the lake has to be removed regularly to prevent foul smell spreading on the pathways. People tend to avoid the pathways due to the smell.

d. Urban Haat:

Urban Haat as part of the ABD region of Anasagar Lake in Vaishali Nagar, Ajmer is located 500-meters from the North-eastern boundary. The Urban Haat project was started on 17 December 2019 and was completed on 31 March 2021. Before this project, informal vendors would occupy the vacant ground abutting the Jila Udyog

Figure-3: New Muscial fountain installed

Figure-4: Pedestrian Pathway around the lake

Figure-5: Sitting spaces in the garden area

Figure-6: Evening peak hour activities

Figure-7: Sagar Vihar A and B: Plan Showing key features

Sangh's Exhibition Centre, which acted as a public magnet. Hence, this site posed an opportunity to cater to the recreational needs of the city.

This study would help us to understand whether such projects will prove to be successful for social needs, the expectations of the involved stakeholders – the shopkeepers, their staff and the public, the gap in the facilities/infrastructure and scope for improvement.

2.2 Key features of the project

2.2.1 Challenges in the project:

a. Lakefront Development of Bird Park at old Vishram Sthali and b. Sagar Vihar Bird Park, Anasagar:

The presence of saline water in the lake as a result of city wastewater discharge has impeded the growth of plants and trees which are essential for the bird population to grow. This has been a major difficulty for authorities both during and after construction. (Ajmera, 2022)

c. Urban Haat:

Limited area was available to develop Urban Haat, leading to limited number of stalls and seating.

2.2.2 Risks involved in the project

a. Lakefront Development of Bird Park at old Vishram Sthali and b. Sagar Vihar Bird Park, Anasagar:

Bird Parks have more environmental risks. Disturbance of the natural habitat of the migratory birds during development of the area near the lake has been a major risk, as it could have driven away the birds. Another risk is that even though the place has been developed for citizens, the increased footfall may disturb the birds.

c. Development of Pathway around Anasagar Lake:

The risks associated with this project are non-business' external operational risks (environmental and social). The proposed width of the pathway should cater to the congestion during peak hours. The pathways are not continuous. This will lead to two-way utilisation of the pathways and may lead to congestion. The cycle track and pathways face the risk of accidents due to the movement of unauthorised two-wheelers.

d. Urban Haat:

Sub-optimal income of shopkeepers and stagnation during off-season and off-festive time, especially in summers.

2.2.3 Features and Benefits

The aspect of social, technical, city administration level impact on the environment and economy of the city. (Expected Vs Observed)

a. Lakefront Development of Bird Park at old Vishram Sthali, Anasagar:

The social influence is evident as individuals are more enthused about visiting the location and there is a greater sense of anticipation. Construction of a musical fountain has helped in increasing the footfalls, especially in the evenings. The park has been developed on a self-sustainable model by leasing out

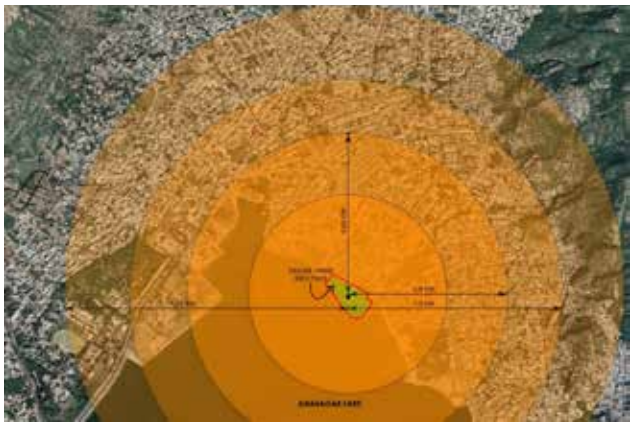

Figure-8: Influence Area of the Sagar Vihar Bird Park

Figure-9: Pathway-1 Measurements

Figure-10: Pathway-2 Measurements

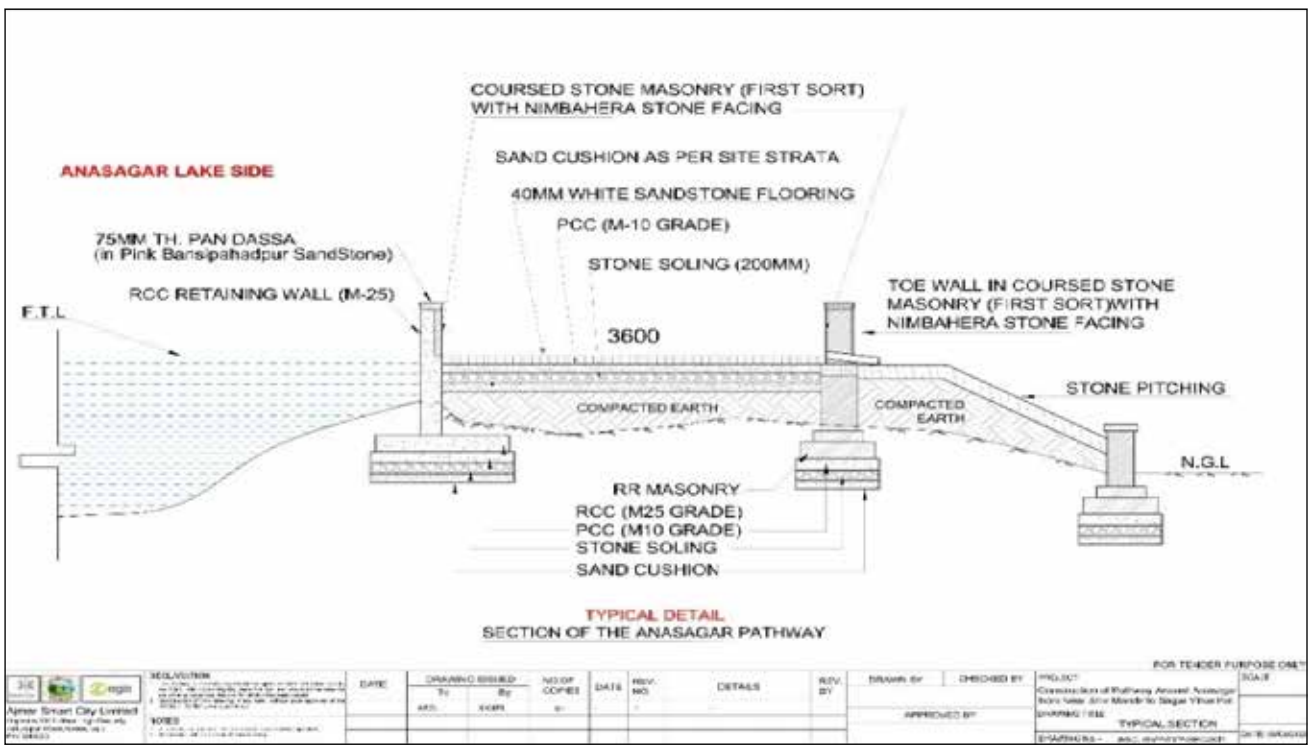

Figure-11: Sectional Details of the Pathways

Figure-12: Site Plan of Urban Haat

spaces for food and games however, more work is required to scale up the facilities to achieve the goal of self-sustainability.

b. Urban Haat:

Expected	Observed
Creation of jobs and fast-paced economic growth	Due to suboptimal footfalls, the economic growth is not as expected
The Haat will act as a venue for various social events	Seeking permission was a significant roadblock to conduct any social event
Stage and AV System for live performances	No provision for live performances
To cater to the heavy footfalls during exhibitions	Limited seating, unable to cater to the heavy footfalls

2.3 Key findings from interviews, surveys and primary/ secondary data collection

a. Lakefront Development of Bird Park at old Vishram Sthali, Anasagar:

Primary survey was conducted on the citizens (Sample size-30) and vendors (Sample size-3). Some key issues that were highlighted:

All the visitors termed the project as successful. There were tourists coming from more than 100-km from Ajmer who were visiting the Dargah Shareef and other prominent places in the city and visited the park (Table-2). More than 60% were locals from nearby areas within a radius of 5-km (Table-1). Most of the families preferred to visit in the evening hours so children could play. Almost 60% were in the age group of 18-30 years. Elderly people and fitness enthusiasts visited in the early hours of the morning and evening for walking/jogging. (Table-3). (Tables in Annexure-1)

Tourists coming for the first time were willing to spend 1-2 hours in the area. Around 80% of the visitors were willing to spend upto 2-hours including local population (Table-6). Some locals who have scheduled visits to hospitals come once or twice a week and other locals visit once a month (Table-5). Nearly 60% visitors were willing to pay entry fees (Table-7). (Tables in Annexure-1)

The vendors were neutral towards the facilities provided. They were satisfied with the general cleanliness and maintenance, lighting and footfalls, but not satisfied with the maintenance of toilets and drinking water provisions. They suggested more shaded seating spaces for the public so the park could be enjoyed during the rains and harsh weather as well. Facilities like CCTV cameras, dustbins and seating were provided by them individually (Table-9). (Tables in Annexure-1)

An important point that came up in the survey was that the citizens were not involved in the suggestion process before the project execution. They only had knowledge that it was part of the Smart City Project (Table-8). (Tables in Annexure-1)

b. Sagar Vihar Bird Park, Anasagar:

Visitors were noticeably pleased with the space and the project was deemed a success. Tourists traveled to the park from more than 100-km from Ajmer, visiting Dargah Shareef and attending wedding functions. More than 60% of the population came from adjacent places within a 2-7-km radius. Majority of the families chose to visit in the evenings so their children could play.

As per the survey with experts (Survey Proforma mentioned in Annexure-2), no public access was allowed in the Bird Park and birds were visible from Pathway-2. The number of birds has increased and a total of 53 species of birds have been spotted in the park. Most of the tourists, including locals, were willing to spend 1–2 hours in the area.

The water level of 6" to 1-feet has to be maintained. But at some places the water level was not upto the mark. Since humans are not allowed inside the Bird Park, pole lights have been provided so people walking on the pathway can see the birds inside the park.

Trees have been planted along the periphery of the Bird Park, and a wetland has been created. To protect the area from any encroachment or trespassing, a random rubble stone masonry boundary wall about 1000-m in length and with a GI wire mesh fencing of about 400-m has been proposed. Signboards are provided along the pathway from the Bird Park to spread awareness about the birds and the wetlands.

c. Development of Pathway around Anasagar Lake:

Experts opine that the scope of the project was to improve health of the residents of Ajmer and provide recreational space and a safe environment in and around the lake and the residential area adjacent to it. There is also scope for creating a vending zone along the pathway.

Primary data collection:

A questionnaire was prepared for the survey, which has been attached as per Annexure-3. Observations and surveys were performed on the on-site data collection and data analysis was done based on various parameters such as: Accessibility, safety, cleanliness, street lighting, cameras, drinking water, public toilets and fencing.

For accessibility, the main gate entry has been provided with vehicle parking space. At intermediate distance, stairs are also provided for accessibility from residential areas. Ramps are provided for physically disabled people.

Maximum footfalls were observed during the evening from around 5:00 pm to 7:00 pm. Satisfactory green spaces have not been created on the pathways. Enough sitting spaces are provided. Street lights were working properly but do not provide sufficient lighting. Lack of security has made the area conducive for illicit activities. There are public toilets near the entrance. Fencing has been done for the Anasagar Lake premises to avoid any further encroachment of the land. Drinking water has not been provided on the pathway. There are no dustbins along the pathways, which affects the cleanliness of the site.

d. Urban Haat:

The present study is exclusively based on a primary survey done with experts; 11 shop-owners and 20 citizens were selected with the help of stratified random sampling. The following was the outcome:

In the primary survey it was found that none of the stakeholders were consulted before/after the project implementation. Only CLAF (City Level Advisory Forum), a public representative body, was consulted. All the shops are being allocated on rent with a 3-year license to run their business. The shop allocation process was done by floating a tender by the Ajmer Udyog Samiti. Free on-site parking has been provided by offsetting the boundary wall to the setback line. Solid waste generated at the Urban Haat is collected by the Municipal Corporation on a daily basis keeping the premises clean.

Some key Issues as per the survey are listed below:

Urban Haat experiences moderate footfalls during weekdays and a little overcrowding on the weekends. Due to space constraints, there are limited seats to cater to the public during overcrowding. Prior permission has to be taken from the Jila Udyog Sangh's Samiti for conducting events due to which very few events take place here. It has also been found that Urban Haat has been commissioned without provision for fire safety and CCTV surveillance, although 2-3 shops have their own private CCTV cameras. No sustainable energy or green building measures have been implemented at Urban Haat.

The assessment of infrastructure provided at Urban Haat by the primary survey has been elaborated in the tables in Annexure-3.

It has been observed that the tourists coming to Ajmer are not very aware of Urban Haat due to lack of proper advertisements. Most locals visit Urban Haat to spend leisure time and enjoy food and the mode of conveyance is mentioned in Table-11. People who are aware of the place are likely to visit the site once a week or once a month (Table-17). The number of males and females visiting Urban Haat are almost the same, reflecting gender equality at such social places (Table-15). People like to visit the area with family and friends (Table-13). The age group of the visitors is mostly 18-30 years (Table-14).

As per the survey, average footfalls per day is approximately 60 on weekdays (Table-12) while on weekends it may increase up to approximately 100. Footfalls during festive time are comparatively more than on non-festive days. Significant footfalls in the evening are from 6-10 pm since during daytime the lack of shade and sitting areas discourage people. Most of

the people are happy with the maintenance of Urban Haat, but toilets lack maintenance (Table-16). The place caters successfully to the social needs of the people (Table-18). As per the survey, the Smart City initiative in Ajmer requires more awareness among the people to make the project successful (Figure-21) (All Figures in Annexure-3)

3. Discussion and Conclusion

The general public is of the opinion that the project is a success and has considerably improved the recreational spaces in the city. Maintenance work is repeated after every three years which is being done by ADA (Ajmer Development Authority). Currently, the AMC (Ajmer Municipal Corporation) is taking care of the Solid Waste Management (SWM). Maintenance and operation of the Park will be handed over to ADA as per ASCL (Ajmer Smart City Limited). Reduction in encroachment, protection of natural environment and availability of public spaces for recreation, have improved the quality of life in the city. Good accessibility to public spaces helps in improving community interactions and thus, the overall living experience of the neighbourhood. The project ensures that all levels of the society are able to enjoy the spaces without any difficulties.

However, there is a pungent smell of the sewer and stagnant water which is present along the water body which can become repulsive while spending long hours in the area. The stagnated water has also become a breeding ground for mosquitoes. Though facilities have been provided but there is scope for further improvement like provision of drinking water, covered seating area for people in the event of rainfall or harsh sun.

In several areas of the lake, the presence of weeds can be observed. This raises questions about the quality of water and the scope of further pollution in the entire lake.

3.1 Implications

The project has turned out to be beneficial for the public especially as it is providing necessary recreational public space for the society and for enhancing biodiversity. Quality of life increases in the surrounding areas for people by adding to the revival of social life, economic opportunities, overall growth of the society and the city. The project successfully aims to create safe, hygienic and viable recreational space.

3.2 Limitations of the research

a. Lakefront Development of Bird Park at old Vishram Sthali, Anasagar:

The limitations of the project were the small amount of time between when the survey was done and the inauguration of the project. Since only two months had passed since the inauguration of the project so the sample size was very small. The involvement of stakeholders was not upto the level required for the survey to be conducted. Also, as the season has changed, the number of birds has reduced which can be analysed efficiently on a seasonal basis.

c. Development of Pathway around Anasagar Lake:

The survey was conducted at only one time of the day due to limited availability of time. During the study, we learned that the users of the pathways also preferred using it in the early morning hours but the team was not able to observe and analyse the pedestrian traffic and activities in the morning. (Survey sample size was 30).

d. Urban Haat:

The findings are a result of the survey done on off-festive days. Since, the survey was conducted on weekdays the overcrowding as reported by shopkeepers on weekdays could not be observed. The involvement of stakeholders was still not up to the level required for the survey.

3.3 Key lessons learned

As the project is deemed successful, it is understood that the public required a recreational and social space in the city. More such projects are needed to reduce the travel distance between the neighbourhoods and the recreation spaces. Such projects help to increase health, happiness, quality of life of the citizens and create more job opportunities. It is important to preserve a large area of natural vegetation to ensure an effective planning for open spaces. Most of the native vegetation provides more benefits to the bird's need for food and shelter, while exotic vegetation gives less benefit (Grund et al., 2002).

Advertisement and promotion of such recreational projects are a must for attracting the crowd. Eateries alone are not sufficient to attract the public – some live performances, music, social events, etc. are needed for the project's success. Also, public participation needs to be encouraged before the execution of such types of projects.

3.4 Recommendations

a. Lakefront Development of Bird Park at old Vishram Sthali, Anasagar:

Some recommendations that are inferenced from the Case Study of The Asan Conservation Reserve in Dehradun, Uttarakhand are: Ensure efficient flow of surface water and prevent water logging along the sides of the park touching the lake. The Master Plan should include provision for development controls and regulations in the zone and measures for tourism planning. These plans should be implemented to avoid uncontrolled tourism development at these locations. The authorities should undertake seasonal monitoring of air, water, noise and soil quality through an approved monitoring agency. The parameters to be monitored should be frequency and duration of monitoring as well as the locations to be monitored.

There is also a need for improvement in infrastructural facilities such as drinking water, maintenance and cleanliness of toilets and security in public space. Also, to create a Smart City the public needs to be provided with sustainable facilities and a higher quality of life for the citizens for which it is important to equip the city with usable recreational facilities.

b. Sagar Vihar Bird Park, Anasagar:

There is also a need for improvement in infrastructure facilities such as CCTV cameras, safety and security in public spaces with sustainable facilities and provide residents with a higher quality of living. It is also essential to equip the city with usable recreational facilities to create a Smart City.

According to the 2017 Guidelines for Implementation of Wetlands (Conservation and Management Rules), untreated waste discharge and effluents from industries, cities, towns, villages and other human settlements is a prohibited activity in a notified wetland. Additional water quality management measures such as chemical treatment may help to reduce the water's foul odour. Water quality could also be improved by increasing the regular inflow of water. Proper precautions must be taken to avoid the destruction of habitat, fragmentation and other related disturbances. Water levels in wetlands that would otherwise experience beneficial drawdowns or water-table fluctuations can be stabilised.

A railing runs along the Bird Park's perimeter, but humans can stride over it. The height of the bars should be increased to 5.5 feet. Strict rules must be enforced to prevent the dumping of waste in the wetland areas.

c. Development of Pathway around Anasagar Lake:

Recommendations as per primary data survey:

Accessibility ramps are provided at intermediate distances and there is restriction on entry of two-wheelers on the pathways to prevent accidents. A suggestion box should be provided at the entry/exit points so as to get feedback from users. Every project has its pros and cons and the Redevelopment Project of Anasagar Lake is not an exception; users tend to avoid utilising the pathways because of the illegal activities and nuisance created by certain groups of people (alcohol consumption, foul language etc). A proper security and surveillance system should be provided to maintain the decorum. At some intervals there should be guards allotted to take instant action against the illegal activities taking place in the area. Signages should be provided to guide users along the pathway.

As per the primary survey conducted, we came to the conclusion that provision for drinking water should be a major concern in the pathways for people using it for jogging and exercise. There should be interconnectivity between the pathways so people can accessit from the surrounding areas and are able to cover the complete perimeter.

Reference: Proposal for Sabarmati Riverfront Development

Solid Waste Management:

The solid waste generated should be properly collected and segregated at source. The biodegradable waste should be converted into a useful end product by treating it in the proposed onsite Organic Waste Converter; and

the recyclable waste should be sold to vendors whereas, the other garbage should be disposed of properly as per the provisions made by the concerned local body.

Safety And Welfare:
Fire-fighting facilities like fire extinguishers, fire buckets near DG sets, in kiosks, toilets and parking areas, etc. should be provided as proposed. Project Proponents should obtain a fire safety certificate/Fire No-Objection Certificate (NOC) from the concerned authority as per the prevailing Rules.

d. Urban Haat:

- AV systems and stage for performances should be provided so more cultural activities like musical events and social awareness programs could be held regularly. Initially, the social events also need to be actively advertised among the public
- Improvisation of facilities such as toilets, illumination etc
- Seating to be made flexible with provision for thermal comfort equipment
- The exhibition centre and the food court should be co-dependent, hence, it is recommended to execute better and more exhibitions showcasing the local artisanary and handicraftsmanship, which will help attract better footfall density.

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Annexure 1

a. Lakefront Development of Bird Park at old Vishram Sthali, Anasagar: Survey Analysis (Citizen)

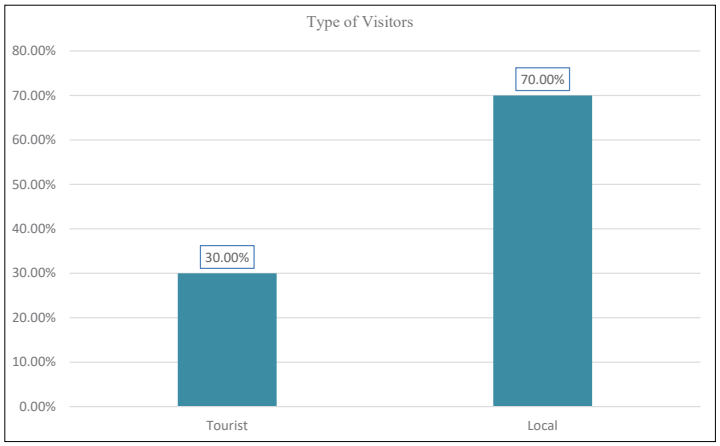


Table-1: Type of Visitors

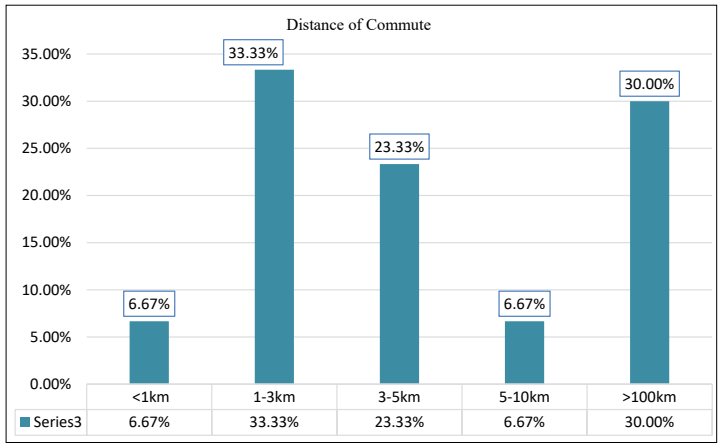


Table-2: Commuting Distance

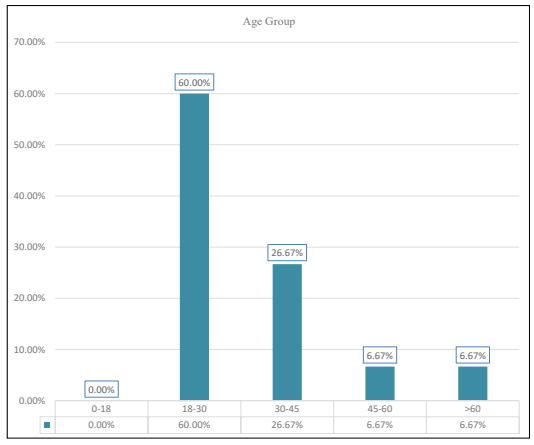


Table-3: Various Age Groups

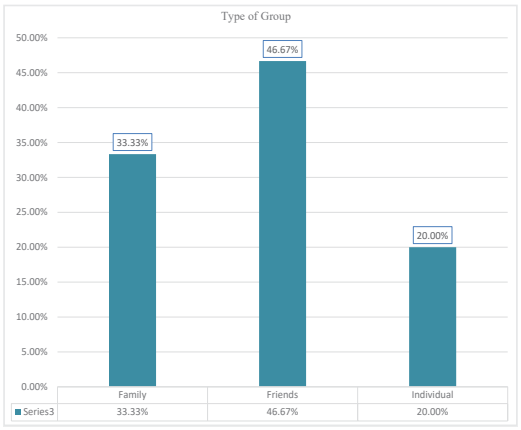


Table-4: Who is visiting with whom?

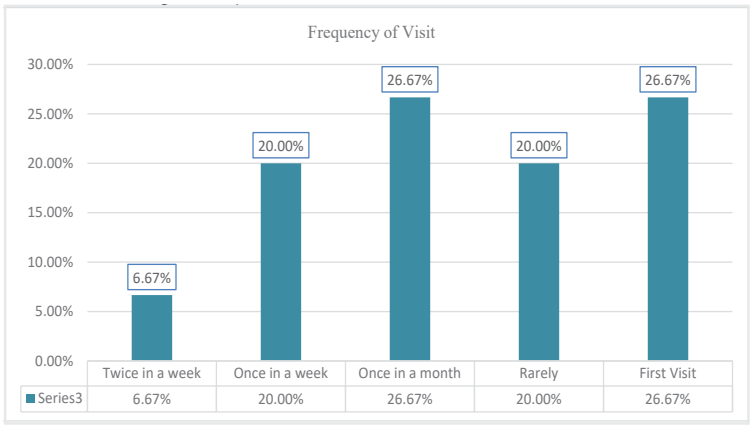


Table-5: Frequncy of visit

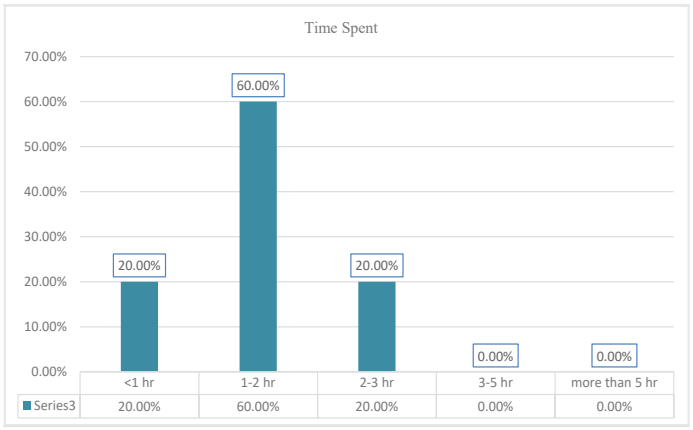


Table-6: Time spent

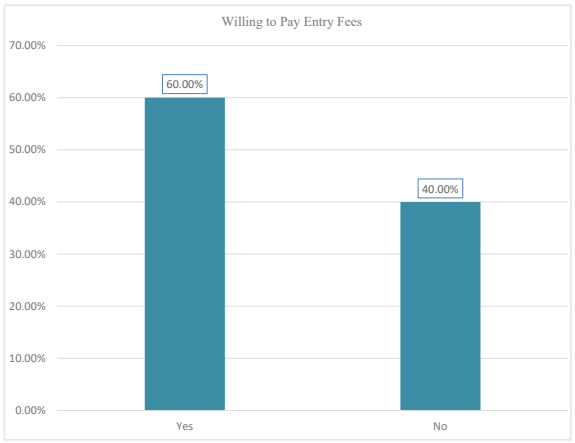


Table- 7: Willing to pay entry fees

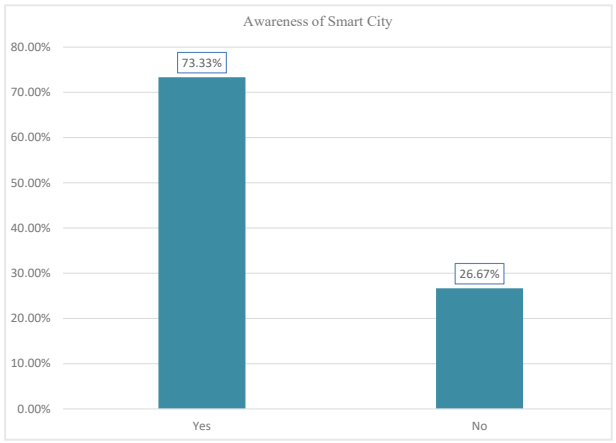


Table-8: Awareness of the Smart City project

Survey Analysis (Vendor)

S.no	Facilities	Yes/No	Not satisfied	Neutral	Satisfied	Remarks
1	Public Toilet	Yes		●		Without water facility & cleanliness frequency is less.
2	CCTV	Yes	●			They have their own CCTV.
3	Accessibility	Yes			●	
4	Street lighting	Yes			●	
5	Dustbin	Yes		●		They have their own dustbin
6	Cleanliness	Yes		●		People avoid sitting in the evening hours due to mosquitoes.
	Street Furniture	Yes	●			They have installed their sittings
8	Operational Hours	11-12 hrs			●	
9	Drainage	Yes			●	

Table-9: Survey Analysis (Vendors)

Annexure 2: Sagar Vihar Bird Park, Anasagar:

Questionnaire For Experts

Name_____

Resident of_____

1. When was this project initiated?
2. What are the parameters involved that helped with selecting the project?
3. Did this project complete on time, and if delayed, then by how much time?
4. Did the task meet the expected outcome? Or, are there any leftover tasks?
5. What sort of challenges did you face while executing the project?
6. Did you face any financial issues while incorporating this project?
7. What were the areas of concern taken up by this project?
8. What infrastructure facilities did this innovative city project work upon?
9. Who all were involved in the planning and implementing of this project?
10. Was there any involvement of the public in this project? If yes, how well did their participation help in executing this project?
11. Do you find involving citizens' opinions in this large-scale project fair enough?
12. Task post-construction: Is the operation and maintenance of the project checked?
13. Which areas would you recommend for this project to be incorporated?
14. Was the pilot project taken into consideration before initiating this project?
15. What is the total cost of the project and other details?
16. What is the model followed for maintenance?

Annexure 3

Urban Hatt :

Survey Questionnaire for Experts

1. When was this project initiated?
2. What are the parameters involved which helped with selection of the project?
3. Did this project complete on time and if delayed, then by how much time?
4. Did the task meet the expected outcome? Or, are there any leftover tasks?
5. What sort of challenges did you face while executing the project?
6. Did you face any financial issue while incorporating this project?
7. What were the areas of concern taken up by this project?
8. On what infrastructure facilities did this smart city project work?
9. Who all were involved in the planning and implementation of this project?
10. Was there any involvement of the public in this project? If yes, how well did their participation help in executing this project?
11. Do you find involving citizens' opinion in such large scale projects fair?
12. Task post-construction: Is the operation and maintenance of the project checked?
13. Which areas would you recommend for this type of project to be incorporated?
14. Was the pilot project taken into consideration before initiating this project?
15. What is the total cost of the project and other details?
16. What is the model followed for maintenance?

Survey Questionnaire for Shopkeepers

1. What is your mode of travel and where do you park?
2. Before this Urban Haat project, what was your source of income and location?
3. Do you have alternate sources of income other than this?
4. What's the time period of the shop license given by the government?
5. Are you getting any type of benefits from the government?
6. What all charges are you required to pay?
7. What is the average daily footfall?
8. What age group of customers do you find the most?
9. Is there storage space for goods?
10. At what time do you find the place most crowded?
11. Do you find the place overcrowded and when?
12. Is more space required for sitting during the time of overcrowding?
13. Do social events take place at Urban Haat?
14. Is this project successful in catering to the social needs of the public?
15. Is this project successful in improving the infrastructure facilities (public toilet, safety, accessibility, lighting, dustbins, camera, drinking water and cleanliness)?
16. How do you manage the waste generated from shops and Urban Haat premises?
17. What happens to the waste water generated at Urban Haat premises?
18. Are you happy with the maintenance of Urban Haat?
19. In what other areas should this type of project be incorporated?
20. Are you aware of the initiative taken by the government for the Smart City Project?
21. Were you involved in the suggestion/decision making of this project?
22. What are the changes you noticed after this Smart City initiative?
23. What other suggestions do you have for the betterment of this project?

Survey Questionnaire for Citizens

1. How often do you visit this place?
2. What is the purpose of your visit?
3. Was the purpose solely for visiting Urban Haat?
4. With whom are you visiting?
5. How many people are there in your group and their age groups?
6. What is your mode of travel and where do you park?
7. From how far do you commute?
8. How much time do you spend here?
9. At what time do you find the place most crowded?
10. Is this project successful in improving the infrastructure facilities?
11. In your opinion, is this project successful in catering to the social needs of the public?
12. Would you be coming if an entry fee is required to be paid in future?
13. Is there a paid parking facility available?
14. In what other areas should this type of project be incorporated?
15. Are you happy with the maintenance of Urban Haat?
16. Are you aware of the initiative taken by the government for the Smart City Project?
17. Were you involved in the suggestion/ decision making of this project?
18. What are the changes you noticed after this Smart City initiative?
19. What other suggestions do you have for the betterment of this project?

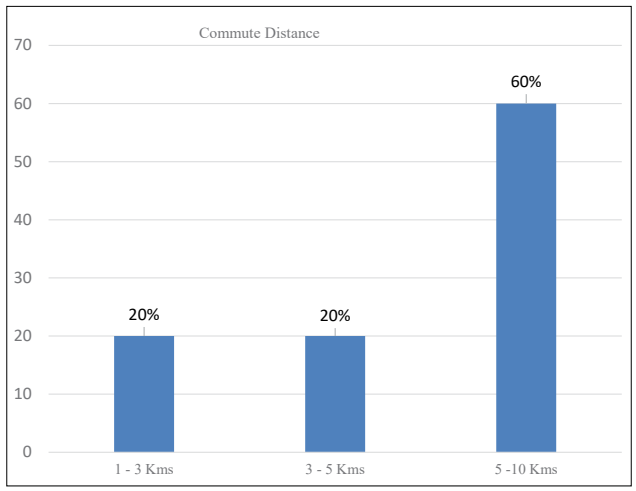


Table-10: Distance of commute for locals

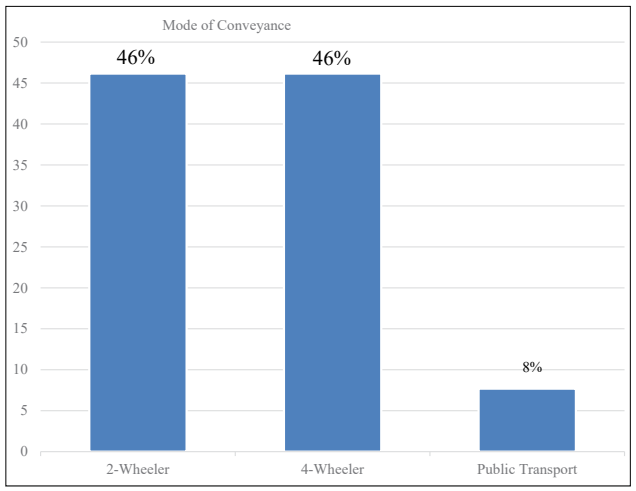


Table-11: Mode of conveyance used by visitors

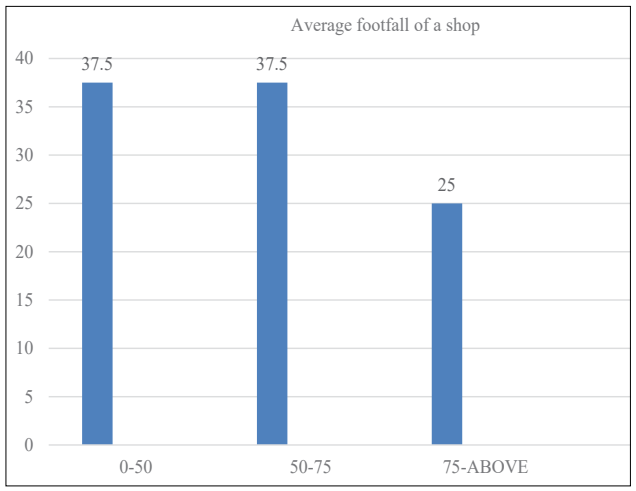


Table-12: Average footfall in shops on weekdays

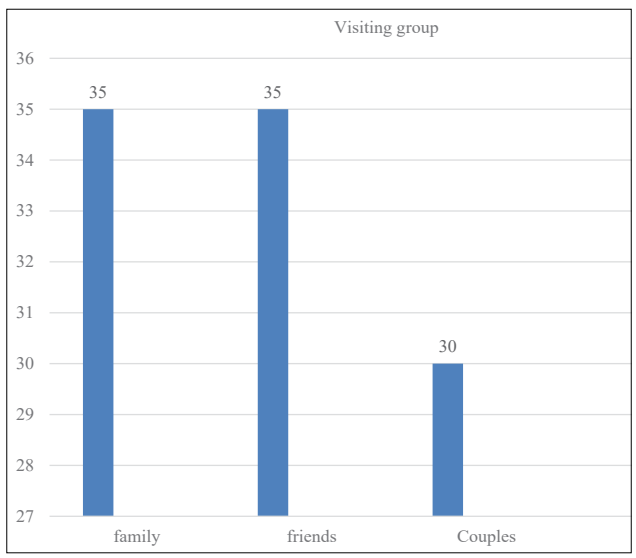


Table-13: Types of groups visiting Urban Haat

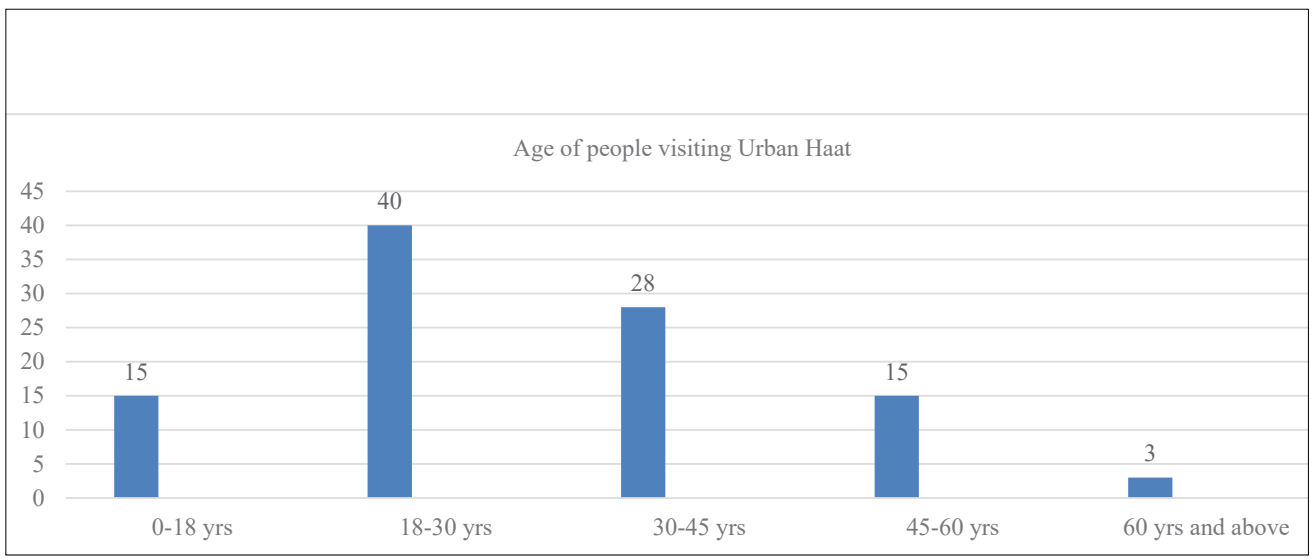


Table-14: Age group of people visiting Urban Haat

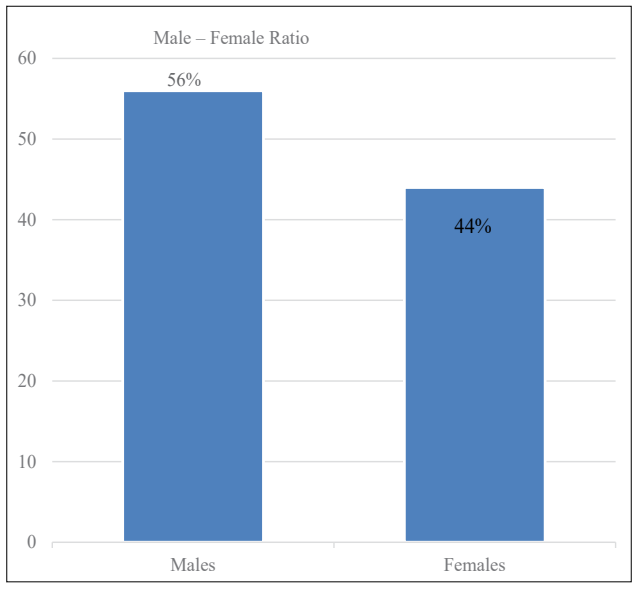


Table-15: Male to female ratio of visiting customers

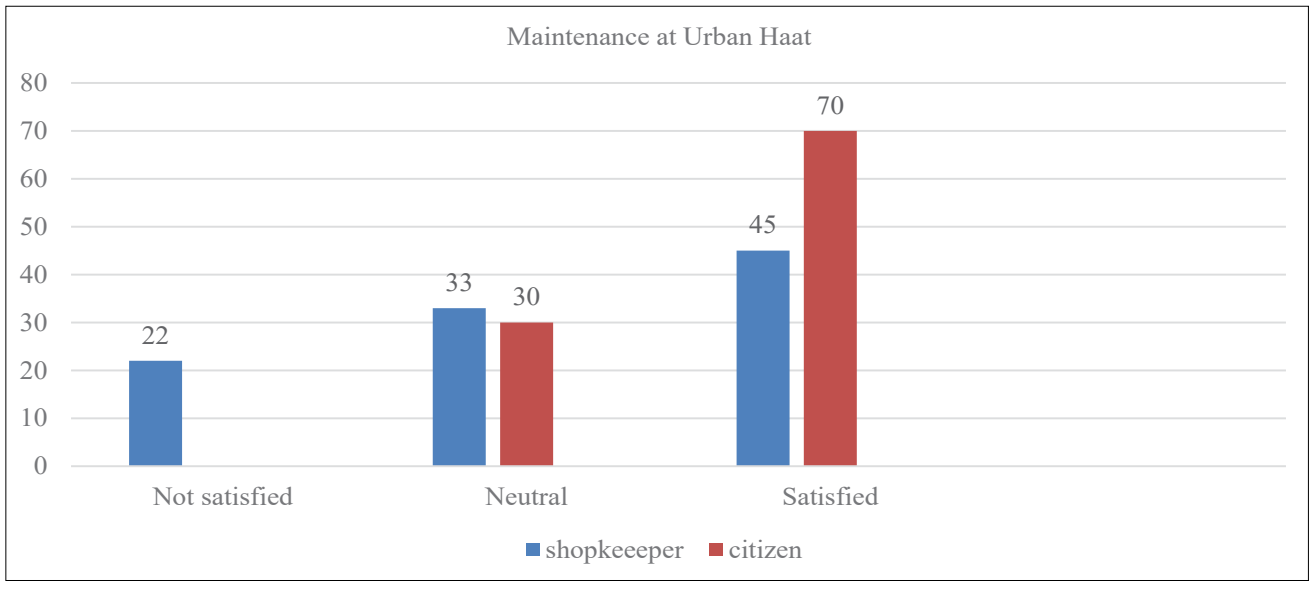


Table-16: Customers and shopkeepers' satisfaction with maintenance.

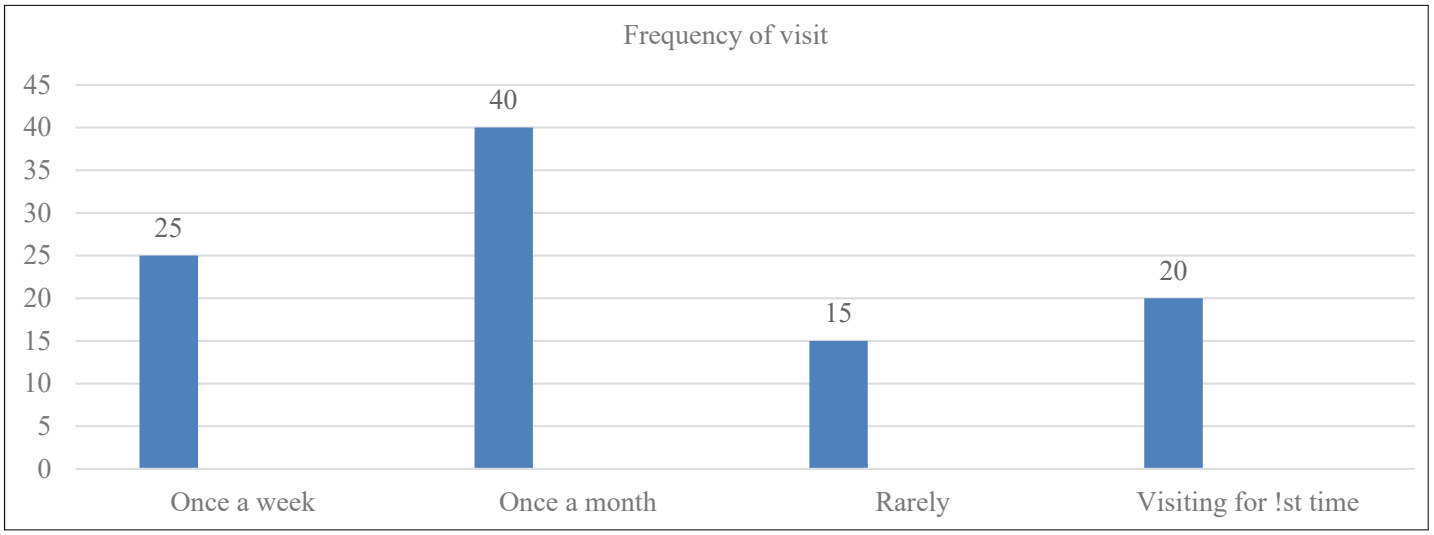


Table-17: Frequency of customers to Urban Haat

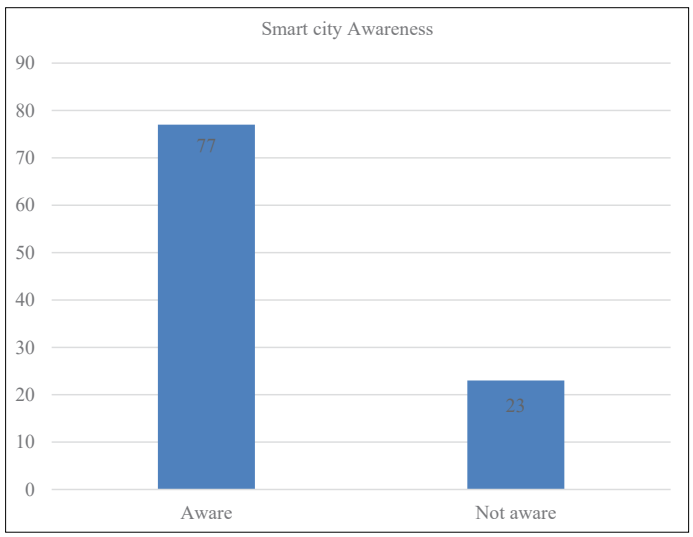


Table-18: Urban Haat's ability to fulfil

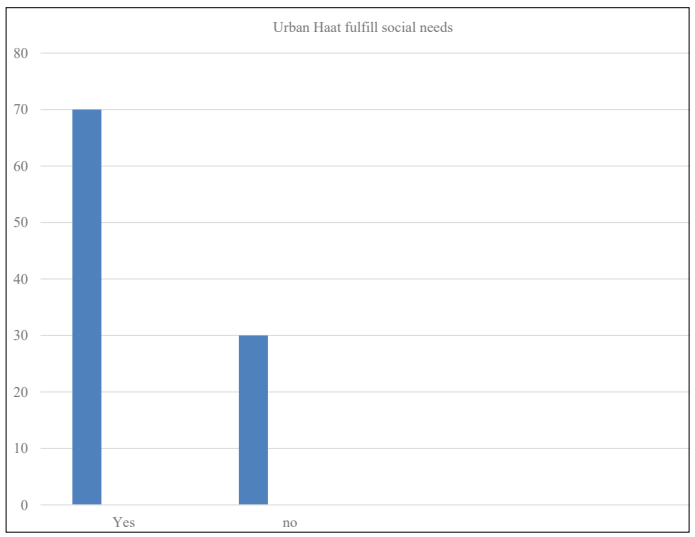


Table-19: Awareness about Smart City initiative the social need

Annexure 4

Sustainable Development Goals:
SDG 3: Good Health and Well-Being.

3.9 Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

3.10 Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

SDG 6: Clean Water and Sanitation

6.3 Improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

SDG 11: Sustainable Cities and Communities

11.3 Enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.

11.7 Provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

SDG 16: Peace, Justice, and Strong Institutions

16.5 Develop effective, accountable and transparent institutions at all levels.

16.6 Ensure responsive, inclusive, participatory and representative decision-making at all levels.

B9

Revival of a Lost jewel- The case of Gujjarkere: Assessment of the Gujjarkere lake rejuvenation for rainwater harvesting and recreation

Location: *Mangaluru, Karnataka*
Year of Project Implementation: *2019*
Sector: *Recreational*
SDG: *SDG 3, SDG 6, SDG 8, SDG 9, SDG 11, SDG 12, SDG 13, SDG14, SDG 15*
Project Cost: *Rs. 2 Crores INR*

Institute: *School of Planning and Architecture, Bhopal*
Advisors: *Prof. Boorla Venkataramana*
Students: *Raghav Chawla, Joshi Aishwarya Anil, Vanlalruatfeli Bawitlung*

Keywords: *Smart City Mission, ecosystem, lake rejuvenation, recreation, rainwater harvesting*

Abstract:

Abstract- Lakes make an integral part of any ecosystem. They sustain substantial biological diversity, help maintain a region's ecological balance, and support life. A freshwater source is a boon to the people living around it as well as to flora and fauna in an area. The primary functions of lakes are groundwater recharge, flood mitigation, habitat for diverse flora and fauna, recreational activity, and tourism. Mangaluru's Gujjarakere lake, spread over 2.7 acres, is the oldest lake in Mangaluru with great historical significance. Before the rejuvenation, the lake had turned into a dumping yard with residential and medical wastes and a breeding ground for mosquitoes. Neglect over the years also contributed to the lake being converted into a marsh filled with silt. After many failed attempts at rejuvenating, this project was added to 65 projects under the Smart City Mission. In 2019, the process of rejuvenation of the lake began and was completed by 2020.

The redevelopment has improved and upgraded the condition of the lake. The lake has also added value concerning social, economic, and environmental aspects. With the rejuvenation, the lake is also developed as a recreational area. The upgraded lake also aims to contribute to rainwater harvesting, which will help during the summer when there are water shortages.

This report discusses the impacts of the rejuvenated lake on its users and the surrounding environment and the SDGs adhering to this project. The study also intends to understand the project's objectives, significance, and data gaps. The key findings made through observation, semi-structured interviews, and study of various literature have also been discussed in the report.

Case Study: **B9**

1. Introduction

Mangaluru is a major port city of Karnataka and an industrial, commercial, educational, and healthcare hub. The city spreads over 170 sq km. Mangaluru City was selected under the second round of the Smart City Challenge on September 20, 2016[1]. The Mangaluru Smart City Limited (MSCL, the Client), under the Government of Karnataka (GoK), had proposed the improvement of Gujjar kere with the allocation of INR 2 crore from the Smart City Mission Fund with the available areas of improvement as:

i. Areas falling within the boundary of the lake.
ii. Immediate areas and access routes around the lake[2].

1.1 Topic and Context

Lakes and their shoreline give a variety of environmental benefits and influence our quality of life and strengthen our economy. Proper lake operation can reduce the impact of floods and drought by holding large volumes of water and releasing it during shortages. Lakes also recharge groundwater, improve the water quality of downstream watercourses, and protect the area's biodiversity and ecosystem.

Gujjarakere is located towards the southern end of Mangalore city. It is surrounded by residential areas and sparse green, providing a suitable opportunity for rejuvenating and redeveloping by improving the recreation and the water harvesting options for the residents and beyond[3]. Rejuvenation of Gujjarkere is a part of the Mangaluru Smart City project. The lake is located towards the southern end of Mangaluru. It is near the Netravati River, which is the main source of water in Mangaluru. The Railway Station, which is the nerve center of the city's transportation, Mangalore Central is within a 3 km radius of the site, while the airport is 17 km.

The extents of ABD and most of the important infrastructure facilities fall within a radius of 1 to 2 km in the southwest direction. Several proposed redevelopments falling within the Smart City Mission are also located within a 5 km radius of the site[4].

The lake was an organic water body until the year 2011-2012. The construction of the stairs around the lake led to the rectangular form that it has today. The site of the lake showed neglect as it was dry with no prospects of rejuvenation. Presently the lake is recharged by rainwater and a nearby river, while there are two outlets along the south-western and western sides, through which the water flows out. Drains are present towards the western side of the lake to which these outlets are connected. A series of concrete steps in the form of an embankment binds it on all sides. The area around the site has a limited amount of greenery with a few native plant species being scattered around. The Gujjarakere road encompasses the lake on the western and southern sides and connects to the Bolar road. This major arterial road connects the lake to the rest of the city. Local roads bound the lake towards the north and east side. With the increased area allocated for residential, the socio-cultural activities and interaction spaces and rainwater harvesting would substantially increase.

Location	Ward no- 52
Area of Mangaluru	132.4 sq. km
Population of Mangaluru	499487
Area of the extents of the lake	2.72 acres
The population of the ward	8075

Table 1 Details of the Ward
(Source: DPR)

1.2 Significance of the Project

i. Gujjarakere is the oldest lake in Mangaluru. Its conservation and rejuvenation have served as a model for the redevelopment of other lakes in the city.
ii. The project aims to improve and upgrade the lake's overall condition.
iii. It promotes self-sustainability regarding rainwater harvest development, aiming to store rainwater and groundwater rising through capillary action.

Figure 1 Karnataka
(Source: Map created in GIS Software

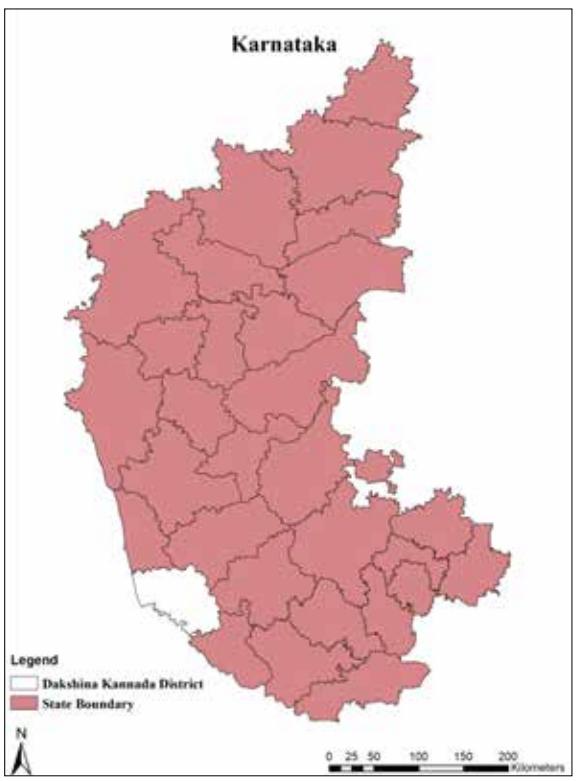


Figure 2 Dakshina Kannada district in Karnataka
(Source: Map created in GIS Software)

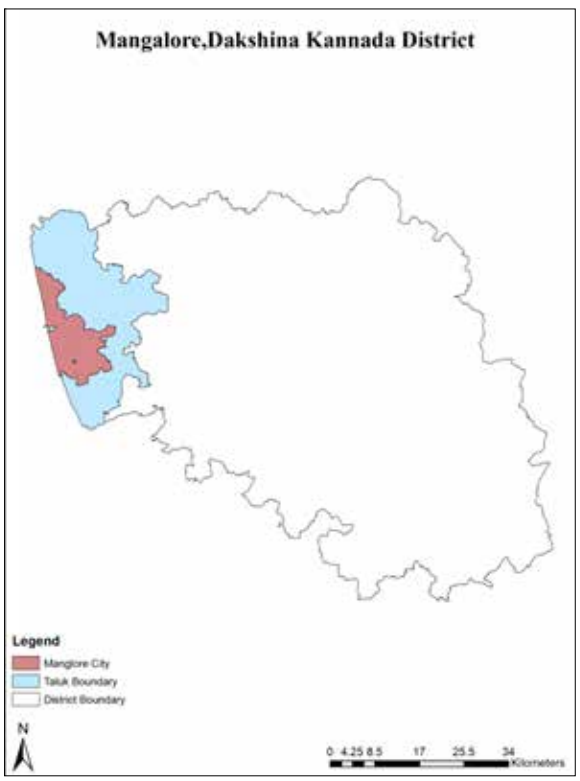


Figure 3 Mangaluru City
(Source: Map created in GIS Software)

iv. The rejuvenation of the lake is focused on recharging the groundwater and providing a habitat for flora and fauna in the area.
v. The project has improved the socio-cultural value of the surrounding area and redeveloped it as a recreational space. With the rejuvenation, the issues like mosquito breeding have been addressed by adding a new purpose to the lake and the surroundings with different activities.

1.3 Aim and Objectives

The study aims to understand the social, economic, and environmental impacts of the rejuvenation of the lake and to critically analyze the project in terms of its functionality and its impact on the users.

The objectives of the study are:
i. To understand the ecological and social impact of the rejuvenation of the lake.
ii. To study the impact of the project through various stakeholders.
iii. To analyze sustainable practice through the Sustainable Development Goal assessment toolkit.
iv. To identify issues and gaps in implementation if any and to provide recommendations for the same.

2. Contextual Background

Spread over 2.7 acres, not only is Gujjarakere the oldest lake in Kudala, but also one of the largest with the historical importance of 1800 years attached to it. The lake is linked to two distinguished saints, Macchendranatha and Gorakshanatha, who lived in the surrounding areas of Mangaluru. Gujjarakere was once the only source of drinking water in the past and religious processions from the neighboring temples of Mangaldevi and Marigudi would pass by this lake and the deity was made to have a jhalaka (holy bath) before proceeding further.

Negligence

Over the years, the development of the surrounding area has polluted the lake by draining the sewage into it. But over the century the religious activities stopped completely. And with the industries coming around in the area, the lake water became polluted. The lake had a lot of drainage seeping into it which became a concern. It became a breeding center for mosquitoes that spread malaria, dengue, and other related diseases.

The Redevelopment processes

Gujjarakere rejuvenation process has been developed by Mangaluru Smart City Ltd, as they identified the lake as in despair. Initially desilting operations were conducted and medical waste and other waste were removed. Water plants and weeds which had choked the water surface were removed with great difficulty. This has significantly increased the number of fishes in the lake.

The project took almost a year to be completed, with the inauguration initially proposed for February 2022 being postponed due to the COVID.

Project framework

Future Proposals

To increase the oxygen level in the pond, in course of time, a small boat model aerator will be provided. Leisure activity like boating is under the proposal. A fountain is in the process of being installed at the center of the lake.

2.1 Conceptual Framework/Research Design

The research has been designed within a framework focusing on assessing and understanding the rejuvenation of the lake project through the qualitative analysis of the Detailed Project Report by Manguluru Smart City limited. Advisory on Conservation and Restoration of Water Bodies in Urban Areas by Ministry of Urban Development Government of India, 2013 has been referred to. This provides a guide to qualitatively analyze the project in terms of the social and environmental impact of the lake and also the impact of urbanization on lakes.

2.1.1 Data Collection methods and analysis

Different types of data collection were carried out, such as observation and understanding of the lake, conducting interviews with the respective stakeholders like the engineers, Smart City officials, and users such as visitors and shop owners, and analyzing different documents and literature.

SDGs and their relevant indicators have been studied and assessed with their role and their impact on the rejuvenation project.

2.2 Key features of the project

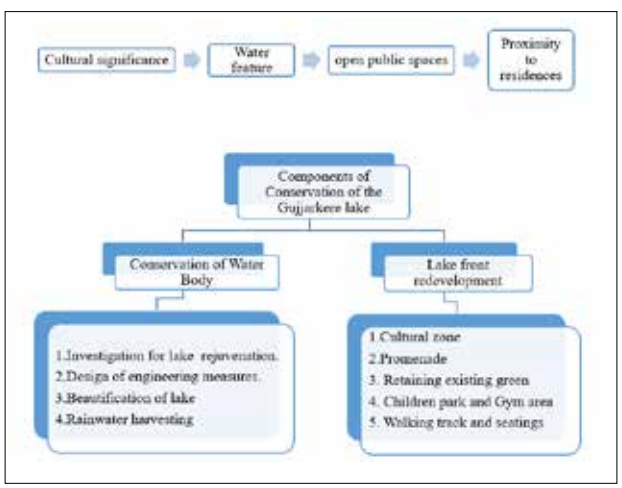
Rainwater Harvesting

Regions in and around Mangaluru receive high rainfall in June, July, and August. The peak rainfall intensity is maximum in October. The average yearly rainfall over the last 36 years comes to 3395.2 mm, which is relatively high compared to the neighboring regions.The contributing catchment area of the lake, approximately 24 Ha, has a concave-like shape with the lake centrally located. The land use of the catchment area comprises different types of developments such as residential, roads, and green areas[5].

2.2.1 Challenges in the project

- Capillary action is used to fill the Lake with water from a little stream in its northeast corner. The creek was encroached upon and covered by settlements over time. Lake was dry, silt-filled, and transforming into a marsh.
- Even though it is located in a residential area, this lake remained underutilized. Locals and inhabitants were unaware that if properly managed, this lake would increase the social and cultural worth of the area. Mismanagement of the property had resulted in waste dumping along the margins and uncontrolled drain overflow.
- Other lakes in the Mangalore area experience the same problems as the Gujjarakere Lake. However, because various lakes have distinct characteristics, problems particular to Gujjarakere Lake were recognized first. physical and social surveys were used to accomplish this.
- Due to financial restrictions and a lack of suitable infrastructure, government institutions lack an understanding of the value of the lake in the area and the need for conservation and maintenance. This is a direct result of little or no investigation into the lake's influence on the neighboring areas.

Figure 4 Gujjarkere Lake
(Source: Map created in GIS Software)



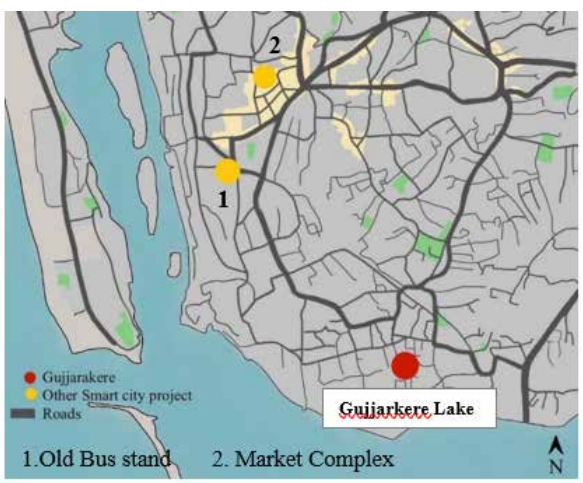


Figure 6 Gujjarkere lake with the city context and other smart city projects
(Source: Authors)

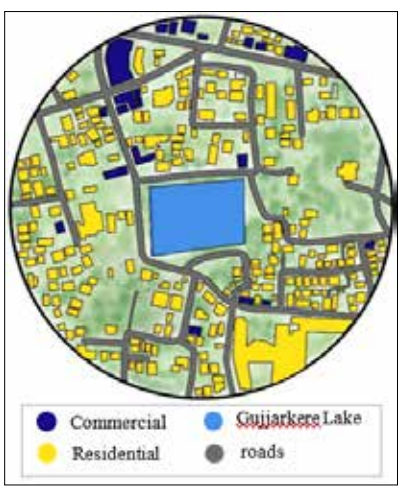


Figure 5 Land use with the lake
(Source: Authors)

2.2.2 Risks involved in the project

Dredging and desilting were tedious processes and they involved a lot of variations, time, and manpower.

2.2.3 Features and Benefits

Infrastructure

i. Design elements such as running and cycling lanes, open gyms, and play areas add value to the space and make it more appealing to locals. The urban design of the lake and its surrounding will enhance the aesthetics and make it more appealing.
ii. After the steps of the pond were repaired, in the interest of the safety of the children and elderly citizens, stainless steel railings were provided around the pond. By the side of the railing, interlocks are laid on a wide area. This is ideal for walking.
iii. Streetlights have been provided around the pond. One side of the pond has been spread to create a play area. Gym equipment has been fixed for young people. Anganwadi nearby too has been turned child friendly. Benches, wastebaskets, a concrete connecting road, and green turf for beauty have been provided.
iv. Some of the trees which stood here previously now exist around the pond. Moreover, 32 new plants have been planted. With the rejuvenation of the lake, the property values of the surrounding residences have doubled, and more properties have come up with this lake.

Social benefits

i. Rejuvenation of a lake not only caters to the storage of water but also results in the development and aesthetics of the adjacent area to the lake.
ii. This development creates a socially engaging area for the nearby residential neighborhood, improving its social value.

Economic benefits

i. When a lake is revitalized, the value of the surrounding properties rises, and a higher property tax may be calculated for these structures. This will strengthen the local tax base.
ii. The proposed boating activities will help in generating added economy to the lake.

Environmental benefits

i. A body of water attracts many bird species and promotes the establishment of various plant species. One of the first noticeable results of lake rejuvenation is the proliferation of plants and animals.
ii. Proper Lake rejuvenation leads to the formation of a microclimate in the surrounding region. The presence of water in the lake all year leads to a significant fall in the temperature in the surrounding region, as well as the formation of local breezes, which provides a calming ambiance.
iii. All nearby sewage pipes are usually treated as part of reconstruction to restrict sewage flow into the lake. The water that enters the lake is a consequence of runoffs, which are then cleansed by the soil on the lakebed, resulting in silt settling and improved quality.

2.3 Key findings from the interviews, surveys, and primary/secondary data collection

The analysis and assessment of the rejuvenation of the lake were based on qualitative methods, which included various documents and literature reading, observations and semi-structured interviews, and empirical understandings. All the methods adopted are characterized by a framework to understand the impact of the lake on the people and the environment.

Case studies

For comparative study, The Kankaria Lake of Ahmedabad and The Jurong Lake of Singapore have been studied. Both these lakes are very context and site-specific with a long history and significance attached to them. Both these lakes have been rejuvenated into popular tourist spots.

i. Kankaria Lake, Ahmedabad

Kankaria is the biggest lake in the city of Ahmedabad, Gujarat. With an approximate circumference of2.3 km, it represents the regale history of Ahmedabad. Kankaria Lake has an approximate circumference of 2.3 km. It was developed in 2006-07 by the Government of Gujarat at an approximate cost of Rs. 36 Crore.

Rejuvenation process

The lake conservation project was not restricted to only cleaning, de-silting, and other lake-related activities, but also included lakefront development for several activities. Facilities like toy train, indoor stadium, laser show, etc are also developed. The lakefront includes a jogging track, aquarium, zoo, park called Naginawadi, and amusement park called Balwatika. The new stadium is designed to hold two basketball courts, a skating rink, a planetarium, an e-library, a multipurpose hall, a gymnasium, aerobics hall, store-rooms, a stage, and different rooms for table tennis, snooker, and other indoor games[6].

Post Rejuvenation

The lake was transformed into a Recreational open public space. The response from the citizens was overwhelming. During the last year, more than 1.18 crore visitors have enjoyed the ambiance of the transformed Kankaria Lake Front. Festivals, small gatherings, educational tours, jogging, informal meetings, picnics, etc. have become the new face of Kankaria to attract the young generation in a meaningful way. Moreover, because of the environment, the ecology of the place has attracted many new species of birds.

ii. Jurong lake, Singapore

Jurong Lake is a freshwater lake and reservoir located in the western region of Singapore. The lake serves as a reservoir contributing to the water supply of the country. The lake is surrounded by parkland, which serves as a recreational ground for nearby residents in Jurong East and Jurong West New Towns. A landscaped sanctuary called Jurong Lake Park exists around the perimeter of the lake. 2.8 km promenade along Jurong Lake Park allows residents to participate in water sports.

The plan was developed in 2008 by the Urban Redevelopment Authority.

The main features of this plan are as below.

Figure 7 Gujjarkere lake before rejuvenation (Source: Mangaluru Smart City Limited)

Figure 8 Gujjarkere lake after rejuvenation (Source: Authors)

Figure 9 The dredging and desilting process Source: Mangalore Smart City Limited

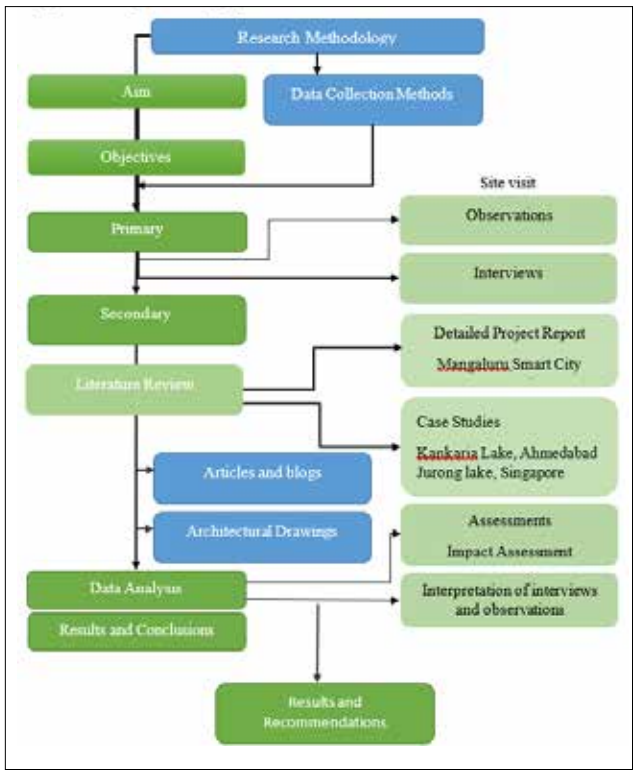


Figure 10 Research Methodology flowchart Source: Authors

i. Some 750,000 square meters of land was planned to be set aside at Jurong Gateway for offices, hotels, food, beverage, and entertainment uses.
ii. 1,000 new private apartments were planned to be built at Jurong Gateway.
iii. The new district to be served by three MRT stations and two major expressways.
iv. The sense of greenery to be heightened with new landscaped open spaces and park connectors at the street level and skyrise greenery in buildings.
v. New Science Centre to be built next to the Chinese Garden MRT Station.
vi. A Lakeside village to be developed, and a Chinese and a Japanese Garden were planned to be enhanced.
vii. An integrated network of pedestrian walkways between buildings and public facilities to be created[7].

Key understandings:

The redevelopment of the lake done by the Smart Cities Mission has been the only successful redevelopment. Before the planning of the redevelopment, a lot of stakeholders were consulted, like the Lake Development Committee and the Area corporator and there was also public participation. As discussed with Mr. Arun Prabha (General Manager Mangaluru Smart City) who said,

"The people-residents and shop owners took active participation and also the pujari of the temple who had an active role in the intervention."

There were no informal settlements around the lake, so there was noconflict relating to ownership. The project cost is 3.7 crores. The lake has a well-defined boundary so there were no encroachments when the Smart Cities Mission took over. There is a nearby river that recharges the lake. This project comes under ABD. The plinth of the lake was built on Vaastu. An aerator has been installed to maintain the quality of the water. The local corporator had problems with the infrastructure because of which a pergola that was initially planned was removed from the plan. People would harm the softscapes, and thus extra care had to be taken to preserve the planted trees. Deeksha Rai (Assistant Engineer Mangaluru Smart City) said,

"When we had initially planted trees, within a day people had destroyed it, and thus maintaining the softscape was a task, and we had to resort to hardscaping more."

Rainwater harvesting is yet to be utilized. Earlier, people would litter near the waterbody and try to jump over, so railings were put on the topmost stairs for people's safety. The lake has improved the value of the context which has increased the property rates of the land surrounding the lake.

Users

The development of the lake has helped the residents from the surrounding residences and also people who work in the vicinity to visit the lake for leisure or recreation.

Kushal, a frequent visitor of the lake, who works in the vicinity said,

"I like coming here during my work breaks, as it is calm and quiet and gives me a break from my everyday routine."

Earlier, the place was unused, but after the project, people came in great numbers for different purposes. Children come to play, and adults and senior citizens come to walk, gym, sit, and relax mostly during the day and evenings. This has increased activities surrounding the shops. Mukta Nagesh, a shop owner who has been working there for a decade said,

Figure 10 Catchment Area Analysis
(Source: Detailed project report)

Figure 9 Kankaria Lake
(Source: Ahmedabadtourism.in)

Figure 11 Jurong lake
(Source: Jurong Lake Gardens)

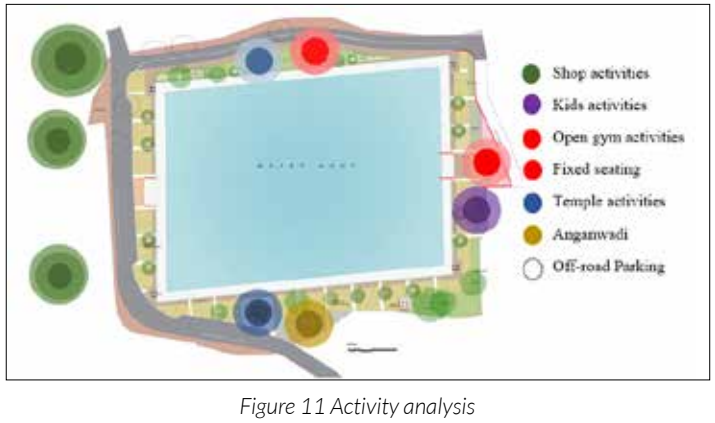


Figure 11 Activity analysis
(Source: Detailed project report and Authors)

Figure 10 Public Plaza
(Source: Development of Lake Conservation Projects, Karnataka)

Figure 12 Jurong lake pathway
(Source: Jurong Lake Gardens)

"I have seen this lake since I was a kid. Back then, women would even come here to wash clothes. We, as kids, would love sitting here and spending time. But when we grew, this lake started getting neglected, and people stopped coming here. We made many attempts to raise this as a concern to local corporators, but all attempts led to no avail. But after the Smart City Mission took over and the construction began, we were finally happy that this lake would regain its lost glory." The area improved after the rejuvenation of the lake. The area is found to be safer even in the late evenings. The residents wish to have a separate 'kund' of the lake which was initially proposed but not implemented yet for the 'jhalak' of the idols during Navratri.

3. Discussion and Conclusion

3.1 Implications

The impact assessments of the lake are based on the social, economic, and environmental impacts.

Social Impacts

i. The lake has increased the social value of the place with people using the space for different leisure and recreational activities.
ii. The rejuvenation of the lake has increased people's activity and interaction.
iii. With the development of the pond, children and senior citizens are seen coming here to have a refreshing walk. In the evening, people can be seen sitting on benches and chitchatting. Small children usually prefer the play area while grownups do exercises in the gym.

iv. Economic Impacts

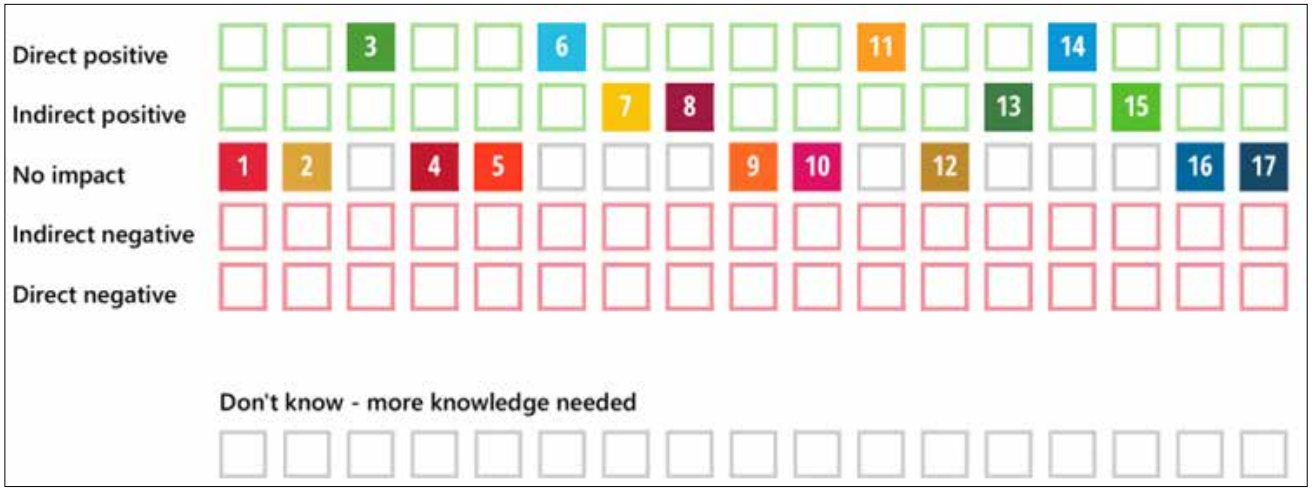
i. There is no fare charged for entry or any other purpose. However, a nominal fare in the future will add to the economy of the lake.
ii. The surrounding property value has increased twice as much as it was before the rejuvenation. More residential buildings came up with the rejuvenation of the lake.
iii. Future proposals such as boating, student camps or visits, or any public activities can help in generating revenue for the lake.

Environmental Impacts

- Due to the cleaning of the lake and its rejuvenation, mosquito breeding has reduced and thus reduced the chances of diseases.
- There has been a significant increase in the types of flora and fauna in the lake. Different types of birds were observed in the lake.
- The rejuvenation of the lake has added to the microclimate of the lake and its vicinity.
- The lake intends for rainwater harvesting. This will help in overcoming water shortage problems during summers.

DG Goal	Impact
Direct Positives	
Goal 3-Good Health and Wellbeing	Lake's rejuvenation was directly in response to restoring clean water from a mosquito breeding ground, which is now improved with the project for good health and the well-being of the inhabitants.
Goal 6-Clean Water and sanitation	The project aims at sustainable management of water quality in the lake. The lake was restored, and the desilting process and removal of weeds were done to restore the water quality. The inlets from surrounding residential areas were also blocked for sewage—only stormwater is allowed.
Goal 11- Sustainable Cities and Communities	The lake has a long history of 1800 years. The lake is a natural heritage due to its cultural significance. This rejuvenation also achieves the target of - providing access to safe and inclusive green and public spaces
Goal 14-Life Below Water	Due to negligence in past the lake has lost its healthy aquatic life, now the Smart City team is putting efforts to restore the aquatic life back and also prevent loss in the future.
Indirect Positives	
Goal 7-Affordable and Clean energy	Hydropower can be generated at the lake's outlet region in the future.
Goal 8-Decent Work and Economic Growth	The fee collection mechanism will generate revenue for the corporation which can be used for the maintenance of the lake. The maintenance work would require a team -generating employment, due to increased footfall in the area smaller businesses can come up in the future
Goal 13-Climate Action	The center is focused on reducing the impact of human activities on the environment through the Smart City mission.
Goal 15-Life on Land	The rejuvenation process also impacts the area around the lake, there is an increase in Flora and fauna around the lake. The project has retained original trees which existed before restoration.

Table 2 SDG Assessments



SDG Assessments
(Source (Sustainable, 2022))

Sustainable Development Goals Assessment
The result comprises five types of relations- Direct positive, Indirect positive, and no impact[8] Indirect negative, and direct negative. *(Sourcc (Sustainablc, 2022))*

SDGs Identified are
Direct positive: 3,6,11 & 4: Have a direct impact
Indirect positive:7,8,13&15: Have an indirect impact
No impact:1,2,4,5,9,10,12,16&17

3.2 Limitations

- Due to the short span since the lake was opened to the public, our assessment is limited to a short time-bound study.
- Our research is limited to qualitative analysis, and it does not look into the issues like water quality.
- Due to the short period of the visit, our analysis does not cover activities throughout the day.

3.3 Key lessons learned

- For any project with a strong historical background and location sensitivity, a local architect or a designer aware of the context closely is crucial. Such projects require a great understanding and knowledge of the place and the context.
- The main priority of any project should be to ensure the availability of basic infrastructure and basic needs before any grandiose design intervention.
- People are very religiously or spiritually connected to a certain place, for them, its values remain significant, and so do their religious demands. (as discussed with the users)

- Maintenance and care are not only the responsibility of the officials but also of the people and the municipalities.
- The design of any recreational space should be inclusive to all kinds of users, for instance, Barrier-free architecture should be present for differently-abled people.

3.4 Recommendations

- A collaborative approach for lake conservation and institutional mechanisms could be provided to facilitate a more straightforward dialogue between various administrative agencies involved in keeping the lake clean and healthy.
- Rainwater harvesting should be given priority to get the maximum benefits from the forthcoming monsoon seasons.
- Instead of giving railings on the topmost stair, the railings could be on the bottom stair, so that the stairs could be utilized by the people for sitting and to have a much closer experience with the water body.
- More softscape should be introduced with more trees, so that during afternoons the trees could provide shade, as not many people were found to be using the space during afternoons. More climate responsive measures are required as the hardscape will cause an urban heat island effect.
- Vendors should be permitted to be working near the lake, as that would increase the people's activities and could generate more economy for the lake. The introduction of social activities leads to greater usage of space and for recreational projects it's a must.
- Public transport should be made accessible to the lake, further increasing footfall.
- The lake has a huge historical significance to it, a separate tank or a designated area for their idol immersion as demanded by the users would elevate the cultural significance of the lake.
- To generate revenue for the maintenance of the lake, activities such as boating, camps, and outdoor activities should be introduced with fee collection.
- Different types of seasonal plantations can be planted around the lake which will add more to the urban microclimate.

DG Goal	Impact
Direct Positives	
Goal 3-Good Health and Wellbeing	Lake's rejuvenation was directly in response to restoring clean water from a mosquito breeding ground, which is now improved with the project for good health and the well-being of the inhabitants.
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Table 3: Impact Assessment

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B10

Livability of Urban Lakes- A Case Of Tolankere: Assessment of the impact of Tolankere lake park in shaping community-level open public space

Location: *Ramlingeshwar Nagar, Hubbali – Dharwad*
Year of Project Implementation: *2018*
Sector: Lake rejuvenation & blue green infrastructure
SDG: *SDG11,13,14,15*
Project Cost: *INR 20.29 Crores*

Institute: *School of Planning and Architecture, Bhopal*
Advisors: *Prof. Boorla Venkataramana*
Students: *Pooja Wadhawan, Priyanka Patra*

Keywords: *Redevelopment, blue-green infrastructure, Lake Ecosystem, public space, Rejuvenation*

Abstract:

Tolankere Lake, also known as Topalgatti Lake, is an important open spacewithin the ABD area of Hubballi-Dharwad city.It is one of the the major water bodies in the ABD area and the second-largest in Hubballi-Dharwad. Under a lake rejuvenation project,Tolankere Lake is proposed for redevelopment to transform and create active community public spaces with recreational facilities. This project is intended to redevelop Tolankere Lake as an active urban space. However, with a dump yard surrounding it, the Lake is filled with sewage & dirt water and due to encroachment by brick kilns, the Lake had become a place for illegal activities. Hence, as a part of the Lake Rejuvenation scheme, the district administration is transforming the Lake into a tourist spot. The fully developed Tolankere lake would be the third Lake in the twin cities transformed to attract recreational facilities.

Case Study: **B10**

1. Introduction

Lakes are an essential component of ecology. They have traditionally served to supply the population's water needs for drinking, washing, agriculture, fishing, and religious and cultural purposes. Aside from these direct uses of lake water, lakes are also known to replenish groundwater and channel water flow to minimize waterlogging and flooding. They also support a diverse range of vegetation and animals, particularly birds.

However, rapid urbanization has led to the unplanned growth of cities and the deterioration of open spaces and community spaces within urban areas. Urban Indian cities face water crisis due to watershed degradation, increasing pollution levels, deteriorating water balance, encroachment, illegal constructions, and a dire lack of groundwater recharge. To meet the rising water demand, augmenting and improving the health of water bodies is of utmost importance.

Hence, as a part of the lake rejuvenation scheme, the district administration aims to transform the lake into a tourist spot. The fully developed Tolankere would be the third Lake in the twin cities to attract recreational facilities.

With this background, the government of Karnataka intends to develop and conserve the lakes in Karnataka.

1.1 Topic and Context

Hubbali, located in Dharwad district of Karnataka, forms the second-largest city in north Karnataka with an area of 202.3sqkm holds a population of 943,857 according to the 2011 census. With the connectivity of Indian railway, it is the headquarters for southwestern railway zone.

Under Hubbali Dharwad Smart City (HDMC), there were four open spaces inside ABD (Area Based Development), identified in the SCP to be developed using SCP funds.One of the projects identified was "Redevelopment of the Tolankere lake for recreational facilities" at Hubbali.

Tolankere lake in Ramalingeshwar Nagar, approximately 1.5 Km from Gokul Road, is considered the second biggest Lake in the Hubbali-Dharwad twin cities with a spread of over 23 acres with landuse majorly residential. It is one of the most significant open spaces within the ABD area of Hubballi-Dharwad city.

Past scenario

Tolankere Lakeoriginated from the name Tolan, meaning fox, and kere, meaning Lake. According to the residents of the Hubbali, Tolankere used to be a water reservoir for the foxes and other species of fauna in the past. The primary source of water into the Lake was obtained from the connected nallah from one of the Hubbali's biggest Lake named Unkal Lake. In 2005, Tolankere lake was dilapidated due to the intrusion of untreated sewage water into this lake, making it a breeding ground for an unhealthy ecosystem, leading to the deterioration of the lake's water quality. In additiondue to lack of maintenance, the lake was converted into a landfill, and with encroachment from the slum, it became a place for illegal activities at the eastern region of Tolankere

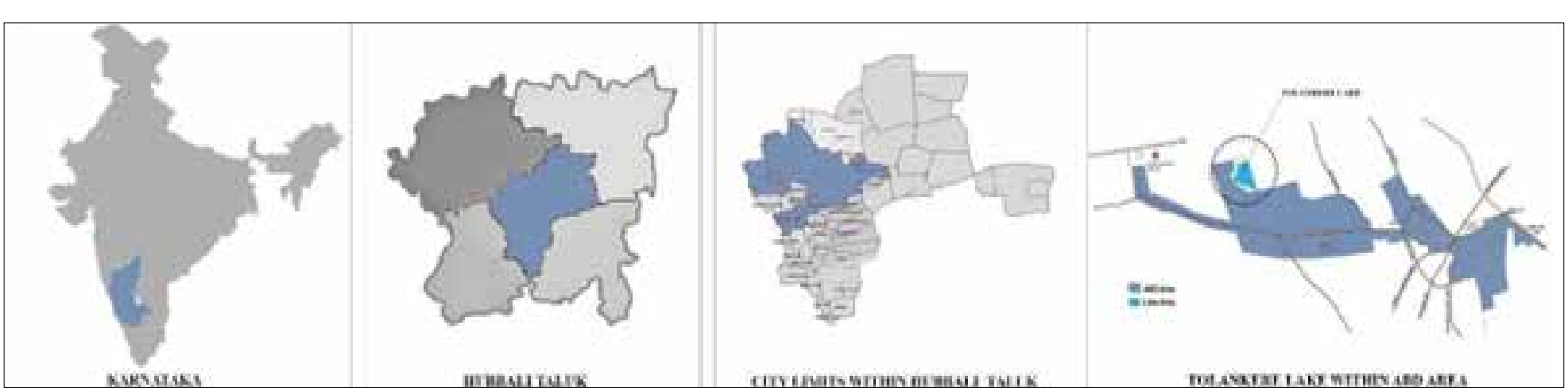

Figure 1.1: Location of the city Hubbali and Tolankere Lake
Source: author

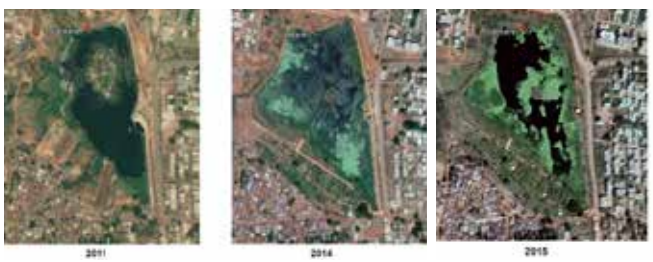

Figure 1.2: Development stages of Tolankere Lake
Image source: Author

Figure 1.3: Unkal lake and Tolankere lake

Figure 1.4: Tolankere lake

Figure 1.5 Tolankere Lake before development & after development

lake. Before the redevelopment of the lake, some of the existing facilities were the jogging track, which was of 3 feet and a pavilion for recreational purposes and a watchtower.

Present scenario

As a part of the lake rejuvenation scheme, Tolankere lake is redeveloped and revived in 3 development phases. The first phase worked on cleaning and improving the quality of the Lake by installing aerators and raptors. The second phase is to develop the lake into a biodiversity park for reviving the ecosystem by converting the dilapidated lake into apark area with community spaces and some recreational activities for the people so that the whole essence of the lake is revived. After development, the lake park has become the second-largest park in the neighbourhood which has changed the image of the place.

Under the project, attempt has been made to investigate and address issues like the maintenance of the lake park and the sustainability of the Lake concerning future prospects, economic impacts, and environmental impacts .

1.2 Significance of the Project

i. The said redevelopment of the Tolankere lake would improve the water quality of the Lake
ii. The health of any urban environment is measured by biodiversity, i.e., the more significant the number of flora and fauna species, the healthier is the environment. Since water as a resource is available in Tolankere Lake, the strategy is to ensure that a large area along the banks is left pervious with soil to support vegetation.
iii. Proposed activities under the project like yoga, jogging track, open gym etc., have proven to be effective ways to keep citizens active and agile. The children's play area is also a much-needed space to encourage children to spend more time with nature.
iv. The properly managed Tolankere lake provides recreational opportunities for the users and a mode of revenue for the Government to maintain the lake, which assists in Rainwater harvesting and protecting the biological resource, enhancing water quality and watershed management.
v. The creation of vending zones (formal/ informal), Food courts and Parking areas creates employment opportunities and jobs for the informal sector and boosts the local economy.

The research problem is to measure the possible impacts of the usage of the developed lake park area on the people and their surroundings as an ecosystem. The proposed lake park is currently not open for public use, and the assessment is carried out based on the evaluation of the designed spaces and components.

1.3 Aim and Objectives

The study aims to understand the present lake redevelopment project and identify the shortcomings in planning and implementation. Through an assessment of the e impact of the developed lake park, it also aims todevelop strategies for the longevity of the Lake through a sustainable approach.

The objectives of the study are :

- To evaluate and model the impact of the developed lake park through the sustainability parameters that would make the lake park sustainable and help achieve its longevity.
- To assess the efficacy of the restoration endeavour in Tolankere lakes, Hubbali, India and understand how the revival of the lake park area adds value to the existing conditions and future aspects.
- To analyse the Sustainable Development Goals and their relevance to the project.

2. Contextual Background

The existing Tolankere Lake of 23Acres under HDMC(Hubbali-Dharwad Smart City) was redeveloped in 3 phases. The first phase of development was the existing lake park area which was left unutilized and redeveloped with landscaping & providing utilities and facilities to make it an active space. The second phase was the undeveloped area which was transformed into an active recreational park with the proposal of a jogging track, gyming, outdoor sports facilities for the community, and the third phase was the water-bound area which was reclaimed by the existing water source from the catchment area and groundwater with an outlet point on the eastern side which further connected the major stream from the Unkal Lake. All the 3phases of development were merged to revive the ecosystem of the Lake.

The Managing Director (MD) - Special Purpose Vehicle was in charge of the project (SPV). The project was managed by the Project Management Consultant (PMC) in collaboration with the SPV and the HubballiDharwad Municipal Corporation (HDMC). The PMC took charge of the project's technical elements. The project's operation and maintenance were carried out by HDMC or a commercial operator who could arrange funds from various sources. The Lake Front Operations were overseen by the Local Development Authority (HDMC), collaborating with the SPV/PMC.

The maintenance of the lake park for its longevity in terms of maintaining the water quality and the proposed facilities of the park was a primary concern that was observed. The project has tried to assess the possible economic, and environmental impacts of the developed lake park area under this project.

The project has also been directly associated with the SDG (SDG11,13,14,15) for lake rejuvenation & development through blue-green integration without harming or destroying local ecology . Assessment of such a project would enable identifying the shortcomings in the planning procedure and implementation. Such evaluation would strengthen the future lake redevelopment projects in understanding the effectiveness of the completed projects, their outcome in conjuction to the sustainable development and its contribution to the holistic approach towards the city in Smart City Mission.

2.1 Conceptual Framework/Research Design

TA qualitative methodological framework has been adapted along with the study of documents (such as DPR) provided by the Hubbali-Dharwad smart city limited to understand and assess the lake redevelopment project. The research aims to assess the impact of the developed lake park area on the end-users by considering the sustainability parameters of urban lakes.

Primary data was obtained through questionnaires to identify and describe the positive and negative outcomes. Documents and drawings provided by the Hubbali-Dharwad Smart City Authority were used as secondary data. This study used a non-experimental, empirical research design. The assessment involved a convenience sample of focus groups, end-users of the Lake, and stakeholders who live in proximity to the Tolankere lake park area.

Fig:6 Play area for kids & toddlers

Fig:7 Gazebos for recreational purposes

Source: detailed project report of hubbali-dharwad smart city

A literature review of essential publications on "integrated water governance and infrastructure" was done. Similar experiences in the water infrastructure and lake management were investigated, and a research problem was identified with relevant research questions. The field visit was carried out to gather data on urban sub-catchments and lakes and how the project components impact the users and vice-versa. An environmental impact assessment was carried out to understand the parameters about the effect of the environment and its designed features on the users.

2.2 Key features of the project

2.2.1 Challenges in the project

- Maintenance of the water quality of the Lake and the availability of the constant water source so that it could prevent further dilapidation.
- Previously, there was no sewage treatment plant in the Tolankere catchment area & non-availability of the complete UGD system was unavailable in the command area.
- At the eastern end of the lake park area, there was an existing slum that encroached with illegal activities in this lake area, which needed to be addressed.
- Maintenance of The developed 23 acres of lake park area for its longevity was a potential concern.
- Availability of adequate resources such as street lighting, parking facilities, and revenue generation for maintenance of the Lake for economic benefits.
- To be able to cater for every age group of society to promote inclusion.

2.2.2 Risks involved in the project

- The developed lake park with harmful anthropogenic activities by the users could impact the surroundings wrongly.
- Lake contamination

2.2.3 Features and Benefits

- Infrastructural

Proposed Activities like Yoga, jogging track, open gym etc., proved to be effective in keeping citizens active and agile. The children's play area was also a much-needed space to encourage children to spend more time with nature.

- Economical

The creation of vending zones (formal/ informal), Food courts and Parking areas created employment opportunities and jobs for the informal sector and boosted the local economy. Therefore, an adequately managed lake provides recreational opportunities for the citizens and a mode of revenue for the Government to maintain the Lake.

- Environmental

The redevelopment of the lake assisted in Rainwater harvesting and thereby protecting biological resources, water quality enhancement, and watershed management

- Social

The social benefits of such a project are not just limited to the people in the surroundings but also to other citizens in the city.

2.3 Key findings from the interviews, surveys, and primary/secondary data collection

The understanding and assessment of the redevelopment project were based on the qualitative techniques of document reading, observation, and semi-structured interviews with various stakeholders (visitors, officials, students) of the project. These techniques were used for understanding the importance of a lake park in a community, the social and economic impact of the project on the end-users, and vice-versa.

- *SecondaryData Collection (critical findings from the DPR and other documents regarding the project)*
  a. The existing facilities at the Lake serve as a recreational space (morning walk and laughter club) for nearby localities. Since the lake is still in development, it has been fencedfrom all sides to preventencroachments.
  b. This area is frequently visited by people of various age groups, especially elderly persons for walking and young children for playing, and this facility is expected to rise steeply once this place is fully developed. The activities are planned to meet the recreational and health requirement of the users.
  c. Proposed activities would promote public health, active communities, and social interaction among the residents/ users.
  d. The water source to the Lake is from the catchment area and groundwater. The Lake has an outlet point (overflow) on the eastern side which further connects to the major Nala, which originates from the Unkal Lake, the biggest Lake in Hubballi-Dharwad.

Fig:8 Features of the developed lake park area
Source: author

e. Currently, the existing sewerage is being discharged into the Lake, which would be arrested by creating a sewerage system and STP. The treated water would be let into the Lake to recharge the Lake. The Lake in itself can act as a rainwater harvest action pit. The lakeshore was developed to protect the edges of the Lake.

- ***Key findings from semi-structured interviews and observation of various stakeholders***

Residents & local people nearby

The questioners for the local people who were frequent users of the lake park area were based on the accessibility, basic infrastructural facilities, and availability of various amenities (drinking water supply, parking, open spaces, etc.)

a. Most of the lake park visitors were satisfied with the facilities such as a wide jogging path, recreational spaces with a yoga park and outdoor gym facilities. However, there were no signages provided for the easy navigation of the lake park in terms of accessibility and safety of children visiting the park.
b. There was a provision of smart toilets for persons with disabilities and such amenities were appropriately structured.

c. Smart city officials

d. The questioners for smart city officials were based on the risks involved in the projects, the aims and difficulties they faced in achieving them. The key findings were:
e. Initially, the project faced difficulty in implementing the activities based on the user requirements in different phases.
f. Previously, there was a slum encroachment from the Lake's eastern region of the Lake, but there has been no separate entry gate provided for them that could have been inclusive.
g. Maintenance of the park was an issue. For this, a five-year maintenance clause has been added to monitor the lake park's cleaning and maintain the Lake's water quality.
h. After the redevelopment of the Tolankere lake, it has become a more significant community hub for the Hubbali Dharwad twin city.

3. Discussion and Conclusion

3.1 Implications

To understand the activities and development of the Tolankere lake, an impact assessment report was conducted with the following parameters that were suitable and relevant to the study.

The impact assessment of the redevelopment of the lake park is based on the selected parameters such as use, environmental sustainability, management in terms of safety & security, inclusion in terms of equitable user experience and engagement in terms of community engagement.

Use in terms of accessibility, physical & psychological comfort

Compared to the previous existing scenario of the Lake, the facilities provided needs to be properly maintained Management in terms of safety & security

Previously, this lake park area before development was encroached by the slum dwellers with illegal activities, creating a safety issue for the users of the lake park; thus, after installing the CCTV cameras and adequate physical surveillance, this area has been assured of safety & security for the users. Users seems to be satisfied with the presence of all the basic amenities like drinking water e toilets; however, there is a lack ofwayfinding signage.

3.1.1 Inclusionin terms of equitable

user experience Provision of the facilities like Boating Facilities, Yoga/Meditation Area, Children' s Play area with equipment, Sand Pit, Designated area for outdoor exercise with Open Gyms, Creation of tree parks and Theme Garden, Aromatic plantations, Walkways/ Jogging tracks, Amphitheatre, Food Kiosks, Fountain, Hedge Maze, Water ATM / Dispenser, E-Toilet / Public Toilet was provided considering the equitable user experience.

Community engagement

The primary idea behind the Lake's redevelopment was the community's engagement for a better experience and improving the quality of user experience at the lake park.

3.2 Limitations of the research

i. Most of the data collected and analyzed in this context has been done on a qualitative basis of data collection.
ii. The opinion of the people during interviews could have been biased.
iii. The redeveloped lake project was not open to all the city users; only the local residents could access the lake park for recreational purposes; therefore, the opinion of the other intended users was not recorded
iv. The quality of proposed elements used in the lake redevelopment has not been considered for the assessment.

3.3 Key lessons learnt

i. The lake redevelopment has boosted the regional economic development in industry, tourism, commercialization and land values.
ii. The landscaping taken in considerations of green areas has helped enhance the urban climate, mitigate the urban heat island effect, and lessen environmental harm by acting as an ecological balancer.
iii. The management of natural stormwater systems and other green infrastructures, such as rain gardens and swales with native grasses, help minimize downstream flooding, recharge and filter groundwater and is proved to be more cost-effective and environmentally sound than artificial pipes and storage systems tanks.

3.4 Recommendations

i. Proper infrastructure such as signages should be provided for the easy navigation and accessibility of the end-users
ii. There could have been a provision of battery cars for the elderly and cyclable paths for the users.
iii. Proper infrastructural facilities for users with disabilities, and the elderlies like the availability of ramps for the easy access of wheelchairs.
iv. The natural method of rainwater harvesting should be promoted.

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B11

Carbon Credit Aggregator Model by Indore Smart City

Name of the project: *Carbon Credit Aggregator Model by Indore Smart City*
Location: Indore, Madhya Pradesh
Year of project implementation: *12 October 2017*
Sector: *Public Private Partnership (PPP Model)*
Project Cost (Rs. Crore): *₹150 crore as of 2021*
Linkages to SDGs: *Sustainable Cities and Communities (SDG 11), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13)*

Institute: *Maulana Azad National Institute of Technology, Bhopal*
Advisors: *Dr. Yogesh Kumar Garg, Dr. Rahul Tiwari, Dr. Surabhi Mehrotra*
Students: *Mr. Utkarsh Kaushik, Ms. Swati Raj Bansal, Ms. Jhalak Agarwal*

Keywords: *Carbon Credit, Carbon Trading, Carbon Emission, Global Warming, Greenhouse Gases*

Abstract:

Companies in the developed countries are compelled by their governments to fulfill specified carbon emission targets. However, if these enterprises are unable to reach their emission objectives, they have the option of acquiring carbon credits from the market, i.e., from someone who has met their targets and has a surplus of credits. Carbon trading is the term for this practice. Carbon trading is particularly beneficial to the developing-world businesses since it tools monetary profits in return for carbon credits, allowing these businesses to acquire or upgrade their equipment. This technological advancement finally aids businesses in reducing carbon emissions. When it was established that companies were the largest polluters of greenhouse gases, contributing to global warming, the necessity for carbon trading became apparent. NGOs and other institutions have made significant efforts to draw worldwide attention to the problem of global warming. However, this issue was not addressed seriously, and consequently, almost nothing was done in this respect. Therefore, it was understood that the only way to draw the world's attention on these issues was to attach a monetary benefit to them. The notion of carbon trading was born as a result. Indore Smart City Development Corporation Limited (ISCDCL) has taken a lead in this mechanism and has achieved a substantial amount by trading carbon credits. ISCDCL has attempted to integrate various projects with positive environmental impact and aggregated them to create a pool of carbon credits for trading in higher quantum, which has fetched motivating results. In this regard, as part of the SAAR programme, documentation of the initiative by ISCDCL has been done in this chapter.

Case Study: **B11**

1. Introduction

The result of contemporary civilization is rapid industrialization. Industrialization is unquestionably important for a country's socio-economic progress, but it should not come at the expense of environment. Fortunately, the profit seekers have finally grasped the actual nature of the ecosystem in which they work, compete, and exist, as a result of which it is their responsibility to rescue the world and sustain industrialization at an optimal level to keep the environment green and safe and avert extinction. It is unquestionable that industrialization benefits society as a whole, but it is also true that its recent speed in pursuit of higher development and irresistible profit has resulted in frequent environmental risks and global warming, posing a severe environmental concern. As a result, proper steps to mitigate the negative impacts of industrialization are imperative. Kyoto Protocol (KP), an international agreement between member nations to limit greenhouse gas (GHG) emissions, may be the right move in that direction. The KP recommends lowering the following GHGs to reduce the detrimental impact on the environment:

- Hydro-fluorocarbons, mainly arising from the filling of and leakage from refrigeration equipment;
- Carbon dioxide, causing about 50-60% of the global warming;
- Methane gas, mainly trapping heat in the atmosphere, and
- Sulphur-hexafluoride, produced by the magnesium production industry, electrical and electronics manufacturers.

1.1 Carbon Credits

Carbon credit is a catch-all term for any tradable certificate or permit representing the right to emit one tonne of CO_2 or the mass of another greenhouse gas with a carbon dioxide equivalent to one tonne of CO_2. The concept of carbon credits came as a result of increased awareness of pollution and the need for pollution control. Carbon credits were one of the outcomes of the Kyoto Protocol, a 192-country international agreement, which established legally binding emission reduction targets for developing countries. To meet these targets, the country must reduce carbon dioxide emissions.

Companies are given a certain "number of credits" that they can use over time. Assume a company is given ten credits and uses only eight of them; the remaining credits can be sold in the market. The two types of Carbon Credits:

- Carbon Offset Credits (COC's).
- Carbon Reduction Credits (CRC's)

Carbon Offset Credits are made up of clean energy sources such as wind, solar, hydro, and biofuels.

Carbon Reduction Credits are the efforts to collect and store carbon from our atmosphere through bio sequestration (reforestation, forestation), ocean and soil collection and storage.

Both approaches are recognized as effective methods of reducing the "crisis" of global carbon emissions. Companies that exceed their credit limit must purchase credits from the market. Carbon trading refers to this method of buying and selling. As a result, market forces reduce overall emissions. The concept of trading emissions for carbon credits is heavily reliant on polluters' ability to gradually but steadily reduce their emissions year after year.

1.2 Significance of the project and Journey of Indore Smart City

Indore Municipal Corporation established Smart City Indore, which incorporates people' engagement in order to qualify Indore for the Government of India's Smart City Mission. The Smart City Indore initiative focuses on governance, transportation, energy and waste management, water management, finance, health and education, infrastructure, and heritage.

Under the Carbon Credit Aggregator Model, Composting, Bio methanation, Energy Efficient Lighting, Sewage Treatment Plant, Bioremediation of legacy waste, decentralized composting initiatives, and others were among the technologies and solutions received by Indore Smart City Development Limited for monetization of green initiatives by EKI Energy Services.

With the financial support from carbon credit, the following projects demonstrated how the carbon credit finance mechanism can catalyze environmentally-sustainable and financially-viable waste management practices. The various projects considered under this activity are:

- Composting
- Bio-Methanation
- Solar PV

1.3 Aim and Objectives

The aim of the study is to document the pioneer Carbon Credit Aggregator Model in India by Indore Smart City.

The objectives of the study are:

a. To understand the functioning of the Carbon Credit Aggregator Model.
b. To understand the possible implementation of this aggregator model in other smart cities with respect to challenges and risks involved.
c. To understand the features and benefits of the aggregator model with respect to clients and the environment.
d. To find out the future prospects of the Carbon Credit Aggregator Model.

2. Contextual Background

Indore has become the first city in the country to generate revenue through carbon credits.

The idea of Carbon Credit came to the minds of the team of ISCDL when they realized that the lack of funding is a common occurrence in urban administration and urban city governance and while looking at these challenges, they also wanted to know how some of the investments that they had already made in this sector could be turned around to generate returns. And as a result, they began investigating the possibility of obtaining carbon credits. Being the first ones trying this concept, they wanted to start small and so they beganwith registering only 3 projects - a bio-methanation plant of 35 TPD capacity (Chhoithram and Kabitkhedi), a 600 tones-a-day compost plant and 1.5 MW solar plant, under the Verified Carbon Standard (VCS) program of the United Nations Framework Convention on Climate Change (UNFCCC). ISCDL started venturing into the uncharted waters, directly dealing with international bodies. They looked for experts, did their research and learned the process of bidding for carbon credits. Ultimately, they grasped the whole process and even started to bid higher.

The overall context of this project in brief -

The project could be divided in two phases:

- First phase: -
  - Indore Smart City successfully registered 3 Projects- Wet Waste Management (Composting), Bio-Methanation and Solar Energy Production.
  - Under the VCS mechanism, along with validation, audit, verification process, 1.70 lakh Carbon Credits were generated during the period 12th Oct 2017 to 30th June 2019.
  - Total revenue of approximately Rs 69 lakhs was released from these credits.

Indore now holds the distinction of being the first city in South Asia to use carbon financing.

- Second phase: -
  - For the period 1st July 2019 till 31st December 2020 of the same projects, Rs. 8.34 Crore revenue was received in September 2021.

Progressing forward, new projects such as Sewage Treatment Plant, Decentralized composting, Forestry Plastic Recycling, LED Lighting, etc. have also been registered in respective eligible carbon credit mechanisms.

2.1 Conceptual framework / Research design

ISCDL started working on Carbon Credits three years ago. In the first phase, Indore Smart City had successfully registered 3 Projects viz:

1. Wet Waste Management (Composting),
2. Bio-Methanation and
3. Solar Energy Production

Indore got the unique recognition of being the first Urban Local Body in South Asia to tap Carbon Finance. New projects such as Sewage Treatment Plant, Decentralized composting, Forestry Plastic Recycling, LED Lighting etc. have been registered in respective eligible Carbon Credit mechanisms.

2.2 Key features of the project

2.2.1 Challenges in the project

a. High project registration charges (e.g., ~$10,000 in VCS mechanism)
b. Complex process flow (requires a dedicated team)
c. Multiple Carbon Credit mechanisms like VCS, CDM, GCC, GS etc.
d. No open trading platforms for Carbon Credits
e. High upfront charges in appointment of DOE, auditor & issuers
f. Accounting of Carbon Credit has a lot of ambiguity involved in it due to lack of proper accounting standards.

2.2.2 Risks involved in the project

a. Fluctuating Carbon Credits market.
b. Carbon Credit Trading creates several taxation issues to the organizations.
c. Carbon Credit Trading encourages the rich to move towards more unsustainable ways.

2.2.3 Features and Benefits to the city (with respect to social, technical, city administration level, impact on environment and economy: expected and observed)

The key features of the projects are:

a. Additional source of revenue with no additional capital investments
b. Carbon Credits proceeds act as carbon financing to the projects (that contribute to emission reductions) which can be used to reduce the net project costs.
c. Source of earning foreign exchange.
d. Improve goodwill and international reputation for pursuing innovative initiatives that contribute to a cleaner planet.
e. Carbon Credit Trading has improved the social status of the organizations.
f. Carbon Credit Trading has resulted in a decrease in overall cost of meeting the emission reduction targets.
g. Carbon Credit Trading helps research and development purposes by providing the funds.
h. Carbon Credit Trading has improved the organizations' market share value.

2.3 Key findings from the interviews, surveys, and primary/secondary data collection

The Smart City Officials outline the entire working procedure in detail:

- They create the essential documentation for submissions after registering these initiatives with the agency.
- The agency then goes through the paperwork, research, and verifies the projects' authenticity and viability.
- Certificates with Carbon Credits are then issued as a result of this.
- These certificates can be traded on the worldwide money-market.

There was no source, blueprint, or instruction manual for Indore Smart City Development Limited (ISCDL) to follow. As a result, the ISCDL ventured into uncharted areas, working directly with international organizations. They eventually deciphered the mechanism and began bidding higher. They were able to achieve the returns of 1.5 percent of total expenditure, despite projections of less than 1percent.

Approaching the global buyers was not difficult. The ISCDL officials followed the Kyoto Protocol provisions and developed proposals that accounted for all the requirements. The most revenue generating projects under the ISCDL are (ranked on the basis of highest to lowest):

1. Wet Waste Management (Composting),
2. Bio-Methanation
3. Solar Energy Production

ISCDL's programs have been successful so far, and have generated a lot of funds for the city officials, but the scope of these programs has more potential as they are each designed to cater to the needs of the future population of the city, so once they are fully operational, ISCDL will be among the pioneers of bringing sustainable development to a settlement.

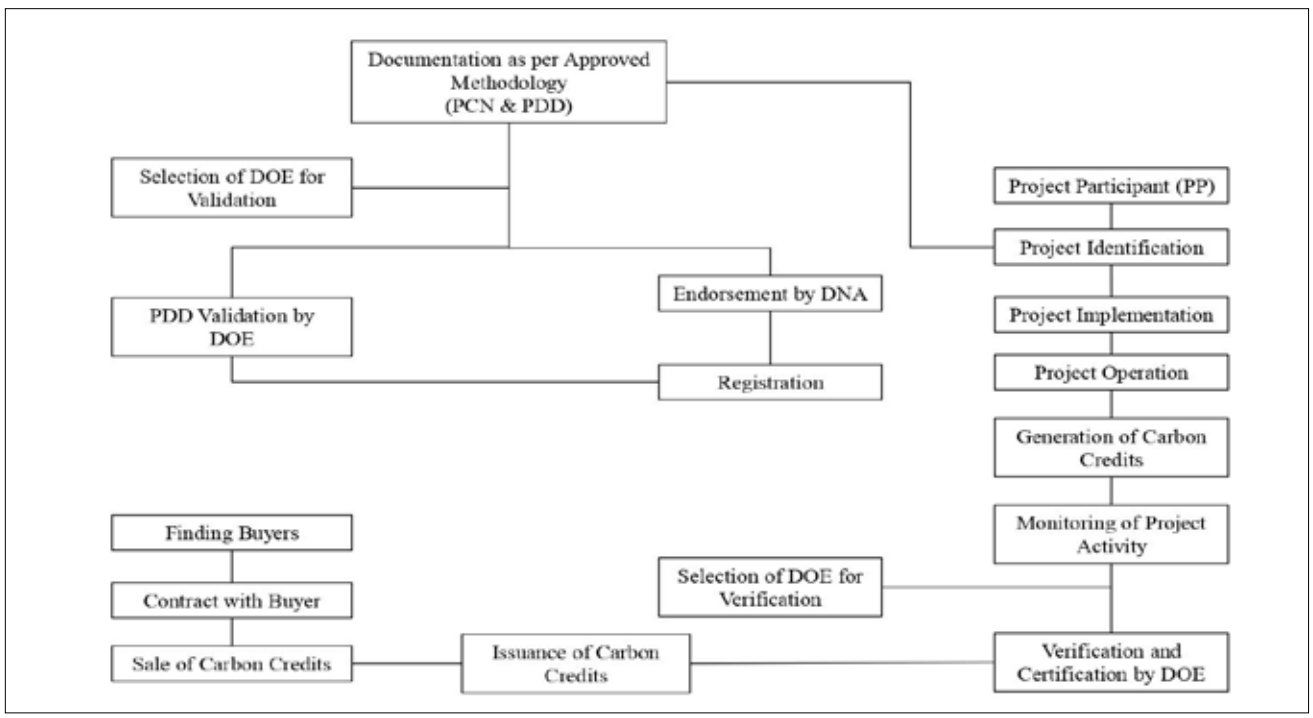
The ISCDL's Carbon Credit Aggregator model is now being sought by other Urban Local Bodies. The Tripura Urban Local Body has approached ISDLC and has requested for details of the model.

A discussion of the model's market strategy was conducted regarding the finances. The price of one Carbon Credit fluctuates in tandem with the rise and fall of the market, similar to holding 'Stocks' or 'Shares'. When ISCDL started collecting Carbon Credits, one credit was only worth 35 cents, but today that price is $ 20.81.

3. Discussion and Conclusion

3.1 Implications

Indore being the first smart city to foray into carbon credit, paved a pathway for other smart cities. Apart from having environmental benefits by saving carbon, it was also able to generate revenue for future projects. While it will take some time to recover the initial investment cost, carbon credit will go on for a long while. The carbon credit projects cleaned the city and gave a financial incentive to the administration of Indore to opt for further green projects. Also, the same model is highly



recommended for other local bodies to gain carbon credits.

3.2 Limitations of the research

- The financial analysis of the investment and its return could not be done in this research;
- The time frame could not be calculated with regard to the recovery of the cost of the projects.
- The in-depth impact of the carbon credit projects on the environment was not studied.
- The future projection about the need of the city, and accordingly the capacity of these projects could not be identified.

3.3 Key lessons learnt

A carbon credit can be generated from the treatment of waste alone, but it also has to take into account how to generate revenue. This is what Indore Smart City Development Limited is doing, i.e. generating revenue from waste in conjunction with its treatment:the conversion of sewage waste into methane to generate more carbon credits for trading.

Bringing together small-scale industries such as agriculture-based businesses that produce a large amount of biodegradable waste and creating revenue from that waste was a wise decision by the Officials of Indore Smart City Office.

3.4 Recommendations

Indore Smart City Development Limited being a successful Aggregator should be given the responsibility by all the ULBs in the State (in the initial Stage) for the Carbon Credit Market to trade the Credits generated by individual ULBs. Alternatively, the business model can be implemented at a National Level with the involvement of the Union Government.

As a successful model, the Carbon Credit Aggregator Model of Indore Smart City should be replicated across the nation on a large scale, for its positive environmental impact and revenue generation for the city.

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B12

Critical Appraisal of Bio-CNG Project under Smart City Mission: A Case of Indore City

Location: *Indore, Madhya Pradesh*
Year of Project Implementation: *2017 (Choithram Mandi), 2018 (Kabitkhedi), 2021 (Devguradiya)*
Sector: *Management and Renewable Energy*
SDG: *SDG 7- 7.1, 7.2, 7.a, 7.b; SDG 9- 9.1, 9.4; SDG 11- 11.6; SDG 12- 12.5*
Project Cost: *Rs.14 cr. (Choithram Mandi), Rs. 5.07 cr. (Kabitkhedi), Rs. 150 cr. (Devguradiya)*

Institute: *School of Planning and Architecture, Bhopal*
Advisors: *Shomit Bade, Dr. Anurag Bagade*
Students: *Damini Rathore*

Keywords: *Bio-CNG, SDG, wet waste, sustainable development*

Abstract:

Waste generation is a common phenomenon in all settlements, but its proper management is not practiced as commonly. The generated waste, if not managed in an efficient way, can damage the environment. One of the best practices for the sustainable and efficient management of waste, in terms of its social, economic and environmental aspects, can be seen in the case of Indore Municipal Area and has been appreciated across countries. According to the Ministry of Housing and Urban Affairs, Indore is the cleanest city in India. It has set a benchmark through the implementation of a Bio-CNG project and by efficiently recycling wet waste generated in the municipal area. The city has three Bio-CNG plants within the municipal boundary. The most recently inaugurated plant is Asia's largest plant for generating Bio-CNG. The plants have a collective capacity of 535 TPD at the city level. The generated gas is used for public transportation in the city and is also sold to other dealers. The corporation is able to execute this project because of public contribution in collecting and segregating their waste at the household level. This contribution acts as a base for the success of the Bio-CNG project in Indore. This project is leading to a reduction of the city's carbon footprint, which is a big step towards achieving the sustainable development goals (SDGs).

Case Study: **B12**

1. Introduction

The Bio-CNG project is an initiative by the government of Indore to achieve their vision of taking the city higher in terms of development. This project has been designed in accordance with the idea of "Imagining Indore to Inherit, Innovate, Include, Incubate and Invest" and make it "an ideal, world-class, smart, commercial metropolis that thrives on investment opportunities, incubating business and ideas, rich inheritance, and inclusive development", which aligns with the national goals of the Smart Cities Mission. The citizens have supported this project and are aware of their role in it, contributing to the best of their abilities, which is a commendable and inspirational act that can be replicated in other cities. This review is a critical appraisal of the Bio-CNG project with respect to its various components, and could be considered for further evaluation of the project's performance.

1.1 Topic and Context

The total waste, including wet waste, generated in Indore is over 1,115 MT (Solid Waste Management, 2020). The Bio-CNG project is based entirely on tackling the wet waste generated daily in the city. The project is a big step towards making development sustainable for the city and has been recognised and appreciated at a global level.

The first Bio-CNG plant in Indore was started in 2017 and was widely appreciated. It was a necessary step towards a greener future for the city. Currently, there are three Bio-CNG plants in Indore that use the city's waste produce as raw material and contribute to sustainable waste management and sustainable energy production. These plants receive the raw material from waste segregated by the citizens and run on a Public Private Partnership (PPP) model. It is a model for economic growth through environmental good practices. Overall, this project is useful for the sustainable growth of the city in terms of energy, economic growth, sustainability and inclusivity, besides benefits for the environment and citizens' health.

For this review, all three Bio-CNG plants in Indore were studied and appraised according to different components. The critical appraisal helped to understand crucial elements from a planner's perspective and weighing the pros and cons of the project.

1.2 Scope of Research

The review has been conducted for all the three Bio-CNG plants present in the municipal area of Indore, Madhya Pradesh. These plants operate on the basis of wet waste generated in the city by a population of approximately 19 lakh people (as per the 2011 Census) spread across the municipal corporation area of 276 sq.km. The population density of the city varies according to the character of the area; the core area has high density and the peripheral areas have low density, as shown in Figure 1. This review focuses mainly on the social, environmental and economic aspects of the project.

The process of generating renewable gas depends on the segregated wet waste provided by the municipality to the plants. Through this, the city earns revenue, as well as fosters sustainability. The scope of study includes understanding this process, documenting the project, exploring the challenges and risks associated with it, including the stakeholder consultations, understanding and incorporating the citizen's perspective towards the project, critically appraising the potential of Bio-CNG, exploring other sectors and their need for renewable fuels, and understanding this project's contribution towards the SDGs.

1.3 Significance of the Project

Before the launch of the Swachh Bharat Mission in 2014, Indore did not have an efficient solid waste management system. There were issues such as open and overflowing garbage bins, and garbage dumping in open areas close to residential, commercial, or public/semi-public areas. Such places were unhygienic and affected the health of people living nearby and the surrounding environment. This situation witnessed a drastic change after the launch of the Swachh Bharat Mission. Indore took an initiative to clean the city, and make it more liveable through sustainable management of waste. The door-to-door collection and segregation of waste at source improved waste management in the city. It became possible to use the segregated wet waste for generating Bio-CNG, a renewable source of energy.

The environmental impacts of the waste management sector reached the transportation sector too. For many years, due to increasing developmental activities in the landscape surrounding the Kanh river, Indore faced numerous environmental pressures. The generation of Bio-CNG has led towards a reduction in such pressures and improved the condition of the environment. Through this project, the city is also working towards collecting carbon credits while earning revenue. Since the PPP model has benefits for the private sector too, the project is also financially viable in the long term.

This project has secured a sustainable future for Indore. Moreover, by managing wet waste to provide a recycled product which does not harm the environment, the project has demonstrated its potential, value, and role in progressing towards the achievement of the SDGs.

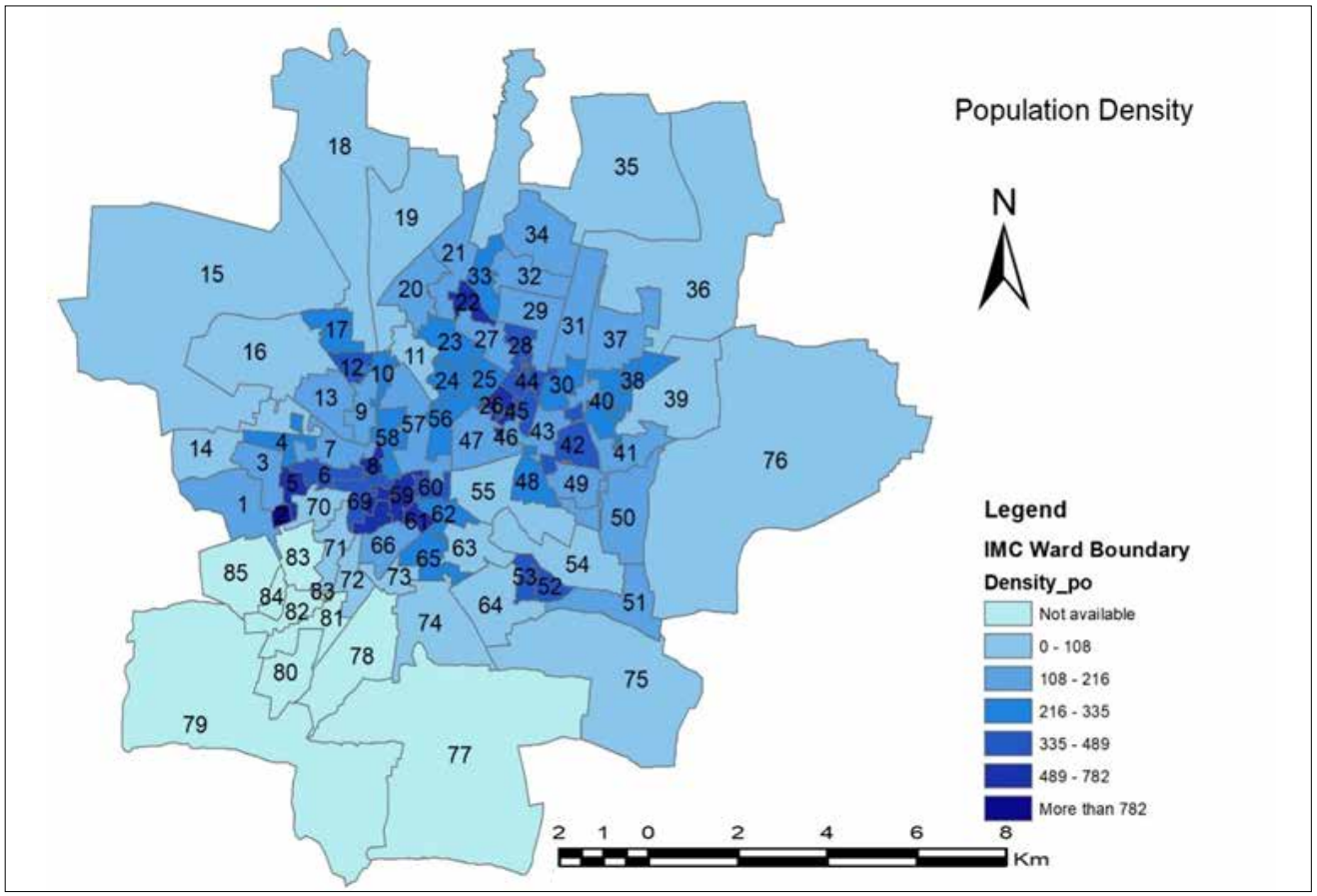


Figure 1: Population Density of Indore

1.4 Aim and Objectives

The aim of the review is to comprehend and analyse the progress and contribution of the Bio-CNG project in the development of Indore.

The objectives of the research are:

i. To document and study the current status of the project
ii. To explore existing and potential sectors for utilisation of Bio-CNG
iii. To assess the environmental implications of the project for the city of Indore

2. Contextual Background

All three Bio-CNG plants in Indore have been considered in this study. These plants are located far from each other and have a different set of characteristics. The Choithram Mandi plant is located in the south, the Kabitkhedi plant is located in the north, and the Devguradiya plant is located in the east of the city. The distance between the three is also worth noticing. The Choithram Mandi plant is 8 km away from the Devguradiya plant, the Kabitkhedi plant is 12 km away from the Devguradiya plant, and the Choithram Mandi plant is 10 km away from the Kabitkhedi plant. If we join the focal points of the three plants, it forms a triangle within the municipal area of Indore, that lies within an 8.5-km radius from the core of the city. The land use in the surrounding areas of the three plants mostly include mixed land use like public/ semi- public buildings, agricultural fields and more. The study of these plants is focused upon exploring certain social, environmental and economic components.

2.1 Conceptual Framework/Research Design

The research conducted on this project includes its documentation, analysis of collected data, assessing its contribution in the development of the city, studying the outcome of the project. For achieving the first objective, site visits to all the Bio-CNG plants in the municipal area were conducted and various aspects noted. The documentation of the plant covers the process of generation and distribution. It also includes stakeholder consultations and primary data collection from the bio-methanation plants. Secondary data could not be shared by the authorities of the bio-methanation plants, however, some secondary data was shared by the Smart City authorities and other institutions that were referred. Then, a primary survey was conducted in the vicinity to understand the role of citizen participation and gather their opinions on the project. Therefore, this study will be based mainly on the primary study conducted.

For achieving the second objective, other sectors were explored to understand the value of clean fuels and the use of renewable energy in the city.

For the third objective, the role of this project in creating a healthier atmosphere for the city was studied in terms of carbon credits with the help of secondary data.

The study will help in highlighting the positive and negative aspects of the project in terms of developmental growth and future sustainability. The study is divided into three components:

i. The social component includes public participation, public opinions, assessment of the outcome of project in terms of citizens
ii. The economic component includes the study of the data for assessing economic feasibility and future implications
iii. The third component is the assessment of the environmental factors wherein the focus is on secondary data from which inferences have been made about the estimated reduction of carbon emissions through this project.

2.2 Introduction to Bio-CNG plants

The Bio-CNG project is based entirely on the concept of recycling organic waste generated in the municipal area. This process uses kitchen waste, vegetable waste, and market waste towards producing clean fuel.

The three Bio-CNG plants within the municipal boundary of Indore are shown in Figure 3.

2.2.1 Choithram Mandi Plant

This plant is located near the Choithram Mandi. It is spread over an area of 7500 sq.m. and produces renewable gas for efficient utilisation in the city. This plant is based on the PPP model and the land has been provided by the Indore Municipal Corporation (IMC) to Mahindra and Mahindra Limited, which is an Indian multinational automotive manufacturing corporation headquartered in Mumbai. Other than the land, IMC is also responsible for providing initial capital expenditure and initial electricity infrastructure, and the company has

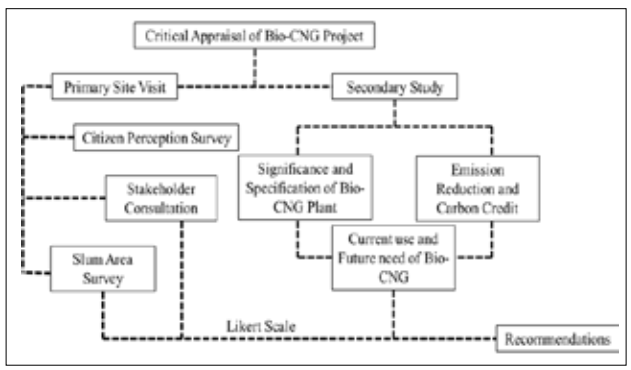


Figure 2: Methodology

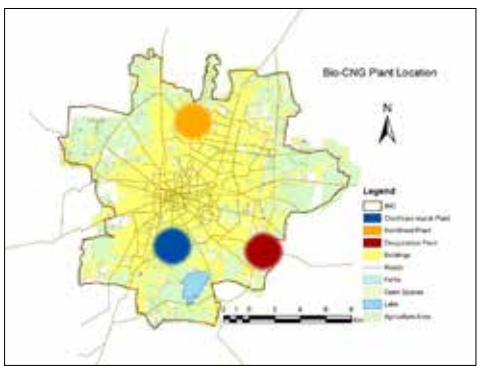


Figure 3: Location of Bio-CNG plants

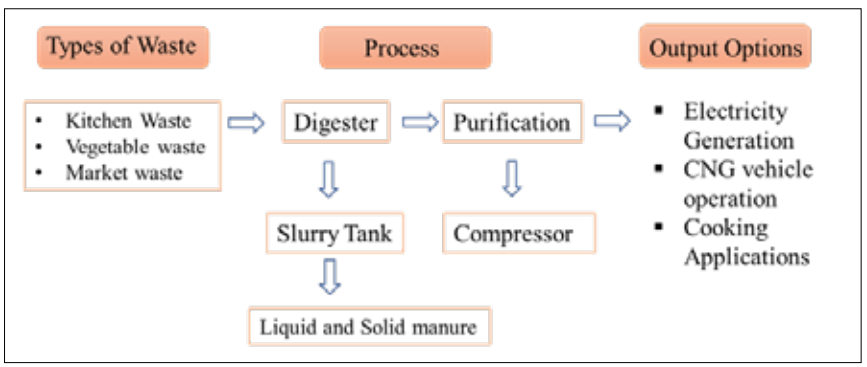


Figure 5: Process flow of the Choithram Mandi Plant

Figure 4: Bio-CNG plant site, Choithram Mandi Plant

to arrange for water, feedstock availability, specialised manpower and the required licenses. The feedstock contains fruits, vegetables, and food waste from hotels, social gatherings, function halls, etc.

The plant is dependent mainly on the organic waste generated in Choithram Mandi. It also takes wet waste generated in the city area from the municipal corporation. The capacity of the plant is 20 TPD, which is used by the corporation to refuel public buses and make them environment-friendly. On a daily basis, it has the capacity for fueling 7-8 buses. However, due to certain issues, the plant authorities have not been providing the Bio-CNG to the IMC and using it only for selling it to other dealers. The cylinders are filled and supplied to Indian Institute of Management (IIM) Indore, nearby hotels for cooking purposes, etc. through a third-party contractor. The plant also produces organic fertiliser of about 3 tonnes per day, which is used by farmers.

For detailed observation, a primary site visit to the plant was conducted and the process of generation and the functioning of the plant were studied. Stakeholder consultations were also done with the officials to understand challenges and risks, future strategies, and public response and opinion of the project.

S. No.	Parameters	Minimum Requirements
1	Location	Choithram Mandi, Indore
2	Plant Capacity	20 TPD
3	Plant Area	7500 sq. m.
4	Plant Owner	Indore Smart City Development Ltd. – ISCDL
5	Plant Supplier	Mahindra & Mahindra Ltd. Mumbai
6	Plant Operator	Mahindra Waste to Energy Solutions Ltd. Mumbai (for 15 years)
7	Operational Since	December 2017
8	Plant Input	1. Organic solid waste generated from Choithram Mandi and other area within corporation limits 2. Water – 5000 LPD – Borewell groundwater 3. Electricity 150 Kwh/day
9	Plant Components	• Input feeder system platform with shed, 10m x 25 m x 6 m (W X B X H) RCC plant form with shed, fencing 15m X 15 m • Mechanical shredder/grinder: 4 tons/hour • Pre-digester Volume: 150m3 • Digester volume : 1200m3, two-stage anaerobic digester with mechanical and hydraulic agitating systems • Remote monitoring system and online dashboard (Analyzers) • Biogas balloons-500 M3 Capacity • Slurry storage tank volume: 200 M3 • Feeding conveyor capacity: 3 tons/hour • Bio-CNG purification plant – 200 m3/hr. Capacity plus 100 m3/hr. • Scrubber moisture: 2 nos. • Scrubber hydrogen sulphide: 2 nos. • Gas compression: High-pressure CNG compressor of min. 120 m3/hr capacity for automatic compression • Gas storage vessel: 10 M3 • Dispensing station for CNG vehicle filling • Cascade cylinder for distribution 1500 kg Bio-CNG gas storage cascade • Captive power backup generator: 1 no. 125 KVA gas generator set • Dewatering system: To separate solid manure from the digested slurry • Organic fertilizer equipment: Loaders, earth movers, sieving machine, compost turner -1 no. each • 200 sq. ft. office room & control room • 100 sq. m. compost platform • Manure storage yard shed (20*12*6m) • Flaring system
10	Plant Output	1. 1600 m3/day biogas converted into 700 kg/day Bio-CNG with more than 95% methane 2. Compost: 2 tons/day
11	End Use of Product	1. Bio-CNG is used as a fuel to operate approximately 7-8 city buses 2. NPK rich organic fertiliser used for farming
12	Capital Investment	Rs. 14 cr. including cost of civil construction & machineries (excluding cost of land)
13	Plant Funding Method	Rs. 7.2 cr. VGF provided by Indore Smart City Development Ltd. (ULB) and balance by Mahindra Waste to Energy Solutions Ltd. (MWTESL)
14	Operation and Maintenance Cost	Rs.10.5 lakh/month including manpower/consumables/equipment repairs/electricity
15	Income by Selling Products	1. Sale of Bio-CNG: 20000 kg/month @ Rs. 60 amounts to Rs. 12.00 lakh/month. 2. Sale of fertiliser produced: 60 tons/month @ Rs. 2000 per ton amounts to Rs. 1.20 lakh/month Total sale amount is Rs. 13.20 lakh/month
16	License and Permissions	1. State Pollution Control Board license 2. PESO license for compressed gas process and storage 3. Factory license 3. Separate license from PESO for dispensing station

Table 1: Specification of the Choithram Mandi Plant

2.2.2 Kabitkhedi Plant

This plant is spread across 4000 sq. m. The plant is based on a PPP where IMC is responsible for providing the land to Mailhem. The plant takes the wet waste generated at the city level from the municipal corporation and has a capacity of 15 TPD that contributes in refueling 10 city buses on a daily basis.

2.2.3 Devguradiya Plant

This plant has a capacity of 500 TPD that also contributes in refueling city buses on a daily basis. The plant is based on a PPP model where IMC is responsible for providing the land to IL&FS Environmental Infrastructure and Service Ltd. The plant takes the wet waste generated at the city level from the municipal corporation.

2.3 Key features of the project

In this section, the challenges and risks involved in the project have been highlighted based on the primary survey and stakeholder consultations with officials from the Bio-CNG plants. Secondary study has also been conducted to understand the basic features of such projects.

Figure 6: Bio-CNG Plant site, Kabitkhedi Plant

Figure 7: Bio-CNG Plant site, Devguradiya Plant

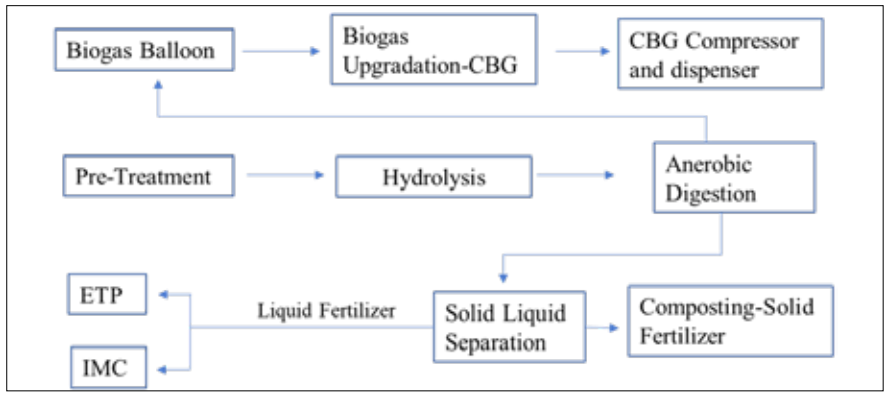


Figure 8: Process Flow of Devguradiya Plant

S. No.	Item	Description
1	Plant Location	Bhangad Road, opp. Kabit Khedi STP Indore
2	Plant Capacity	15 TPD
3	Plant Area	4000 sq. m.
4	Plant Owner	Indore Municipal Corporation, Indore
5	Plant Supplier & Operator	Mailhem IKOS Environment Pvt., Pune
6	Operational Since	1st January 2019
7	Plant Input	• Organic solid waste collected from municipal area • Water: 4000 ltr/day • Electricity: 130 Kwh/day
8	Plant Output	Raw biogas: 900-1000 cum/day converted in Bio-CNG/CBG of 450 kgd/day Compost: 1.5 ton/day
9	Utilisation of Product	• Bio CNG is used for fuelling AICTSL buses • Compost is used for horticulture/agricultural purposes
10	Manpower Requirement	• Plant In-charge: 1 • Maintenance Officer: 1 • Biogas Section Operator: 1 • Helper for waste loading: 8 • Bio-CNG Section Technician: 2
11	Capital Cost	Rs. 5.07 cr., including civil work site development, machinery, electrical work, etc. (excluding cost of land)
12	Operation & Maintenance Cost	Rs. 7.0 lakh/per month, including manpower/consumable/ equipment
13	Income/Savings from Sale of Products	• Sale of 450 kg Bio-CNG/day @ Rs. 60/kg • Sale of fertiliser produced (45 tons/month) @ Rs. 2000 per ton amounting to Rs. 90,000 • Profit through current year/last year sales = Rs. 24 lakh/year • Production, cleaning and operational cost and savings after that = Rs. 24 lakh/year. • Overall income/saving from the products per month = Rs. 2 lakh/month

Table 3: Specification of Devguradiya, Source: Smart City Cell

S. No.	Parameters	Minimum Requirements
1	Location	Devguradiya Trenching Ground, Nemawer Road, Indore
2	Plant Capacity	500 TPD
3	Plant Owner	Indore Municipal Corporation, Indore
4	Plant Supplier & Operator	IL&FS Environmental Infrastructure and Service Ltd.
5	Operational Since	Phase 1 (200 TPD) is planned to be commissioned by April 2021
6	Plant Input	1. Organic solid waste generated within municipal corporation area 2. Power requirements in kwh/day: 1MW 3. Water requirements in KLD: Initially 5000 Kl (For O&M, reused water will be used)
7	Plant Technology	The project is based on the semi-dry mesophilic digestion approach for large-scale Anaerobic Digestion (AD) Plants The AD reactors work on the principle of temperature-controlled semi-continuous mixing technology A robust temperature control module ensures an optimal temperature range of 38-41oC The plant biohealth monitoring is based on a patented and international award-winning biohealth monitoring technology
8	Plant Products	1. Target raw biogas production is a minimun of 40,000m3/day which is converted to 16000 kg/day of Bio-CNG 2. Output slurry is converted to compost
9	Bio-Gas Specification	CH_4 >96% CO_2 <4%
10	End Use of Product	1. Daily expected Bio-CNG usage At IMC dispensing station to fuel 100 CNG buses with 80-kg CNG tank each per day: 8000 kg By GAIL: 8000 kg 2. Liquid soil conditioner as well as solid compost will be supplied to farmers
11	Capital Investment	Rs. 150 cr. under PPP mode (including cost of civil construction & machineries and excluding cost of land)
12	Funding Method	1. Under PPP Mode, all civil infrastructure, site development, machinery, and electrical work done by IL&FS Environmental Infrastructure and Services Ltd. 2. Land provided by Indore Municipal Corporation free of cost
13	Operation and Maintenance	O&M contracted to IESL for 20 years
14	Income by Selling Products	1. Sale of Bio-CNG to IMC to fuel 100 city buses and to GAIL 2. IESL will pay Rs. 2.52 cr. annually to IMC

Table 2: Specifications of Kabitkhedi Plant, Source: Smart City Cell

2.3.1 Challenges for the Project

i. The availability of labour is not certain, and the process depends on it
ii. Labourers have to segregate the segregated waste, which shows a lack of awareness among citizens

2.3.2 Risks Involved in the Project

i. The wet waste has to be given on a daily basis to the plants otherwise it can affect production
ii. Door-to-door segregation has to be maintained by IMC as it acts as the base for the project
iii. The wet waste has to be given on a daily basis to the plants otherwise it can affect production
iv. Door-to-door segregation has to be maintained by IMC as it acts as the base for the project

2.3.3 Features and Benefits for the City (Expected and Observed)

i. The city has been able to generate carbon credits and has earned funding from governmental institutes
ii. The project has changed the scenario of the city in terms of sustainable practices
iii. This project has set a benchmark for other cities and contributed in reducing harmful carbon emissions

2.4 Key Findings from Interviews, Surveys and Primary/ Secondary Data Collection

2.4.1 Stakeholder Consultations

Discussions with the Plant Head or higher authorities of the Bio-CNG plants took place along with the primary visits to all the three plants. There was a set of questions asked to know their opinions on the project, future strategies, benefits, risks, challenges and more.

An increasing population will also increase waste generation that may pose a burden on these plants as they have limits on their capacities. However, during a discussion with Nodal Officer Saurabh Maheshwari at the Smart City cell, he shared that this project will suffice for the waste generated by the population until around 2042, which shows good potential.

The inferences from the discussions with other stakeholders such as the Plant Head at the Choithram Mandi plant, Technician at the Kabitkhedi plant, and the Environmental Specialist at the Devguradiya plant are shown in the table below. The numbers 1-4 represent the opinion of the four stakeholders mentioned above.

2.4.2 Citizen Perception

A primary survey was conducted within a 1-km radius of the three Bio-CNG plants for understanding and assessing the perception of citizens. A total of 30 samples was collected, with 10 samples for each plant. Shopkeepers, street vendors, people staying in the area, and other relevant people were surveyed. They were asked about their opinions on the projects, if they want any improvements in the city, and if they face any issues due to the projects. The inferences from this survey are shown below.

2.4.3 Slum Area

For understanding the need for clean fuel in a different sector, a primary survey was conducted in five slum areas in different localities within the municipal boundary of the city. These slum areas, namely, Mali Pura, Arjunpura at Mhow Naka, Amar Tekri, Sikandarabad Colony and Kadav Ghat Basti, were selected based on census data regarding their choice of fuel and infrastructure availability. A document from the Centre for Urban and Regional Excellence that deals with slum areas was also referred to for selecting the areas.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Does public participation acts as a base for the success of this project?	4				
Public awareness is what other cities need to learn from Indore and replicate.	3	1			
Does the city need to produce more renewable energy for its sustainable future?		3	1		
Should the city look forward to other projects in the sector of sustainable energy?		1	3		
Does this project contribute in improving the environmental condition of the city?	4				
Should Indore switch entirely towards clean fuels for transportation services?		2	2		

Table 4: Likert Scale on Stakeholder Opinions

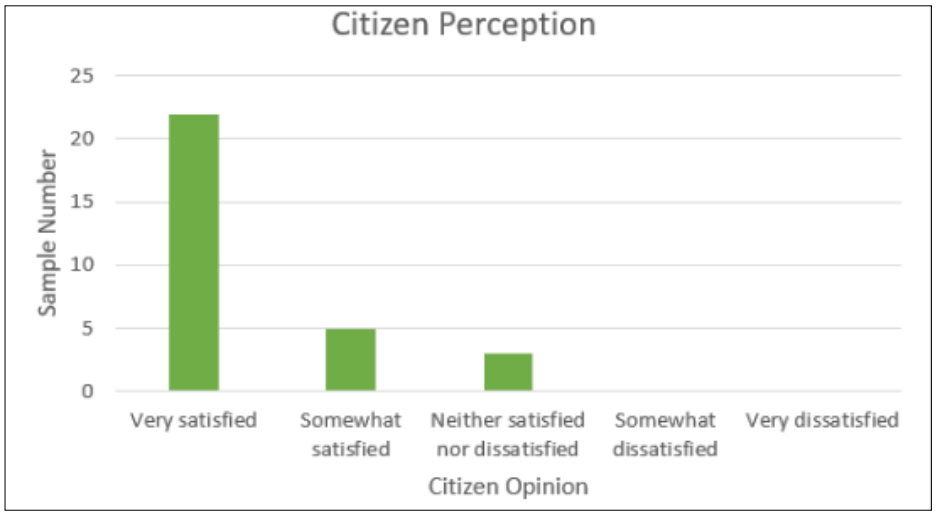


Figure 9: Citizen Perception on Bio-CNG Project

Figure 10: Survey of Five Slum Areas in Indore

During the primary visit, it was observed that people often use firewood, cow dung and other unclean sources of energy that eventually affects the environment of the city. The main reason for the use of unclean fuels is their affordability and other personal choices. The scenario in the slum areas is visible in the photographs below, which were taken during the visit.

The Bio-CNG project is generating clean energy for the city to make it sustainable and earn revenue but the use of unclean fuels in such big amounts will still affect the environment adversely. Thus, there is scope for more interventions by the government in terms of stopping activities that use unclean fuels. This would require proper policy support, strategies and coordination from the government departments.

2.4.4 Carbon Credits

By implementing various projects, Indore has earned a good amount of carbon credits, which has become a source of revenue for the city, and is working hard to earn more carbon credits in the coming years. From October 2017 to December 2020, the city has contributed to an emission reduction of a total of 3,39,913 tCO_2e, which includes composting plants, the Bio-CNG plants of Choithram Mandi and Kabitkhedi, and a solar plant of 1.5 MW. Due to unavailability of data after 2020, data from 2018 to 2020 has been shown in the tables below. The data for the Bio-CNG plant of Devguradiya is not available as it was inaugurated in March 2022 and data on its contributions will be available after a year, as per discussions with the officials.

2.4.5 Bio-CNG Usage in the City

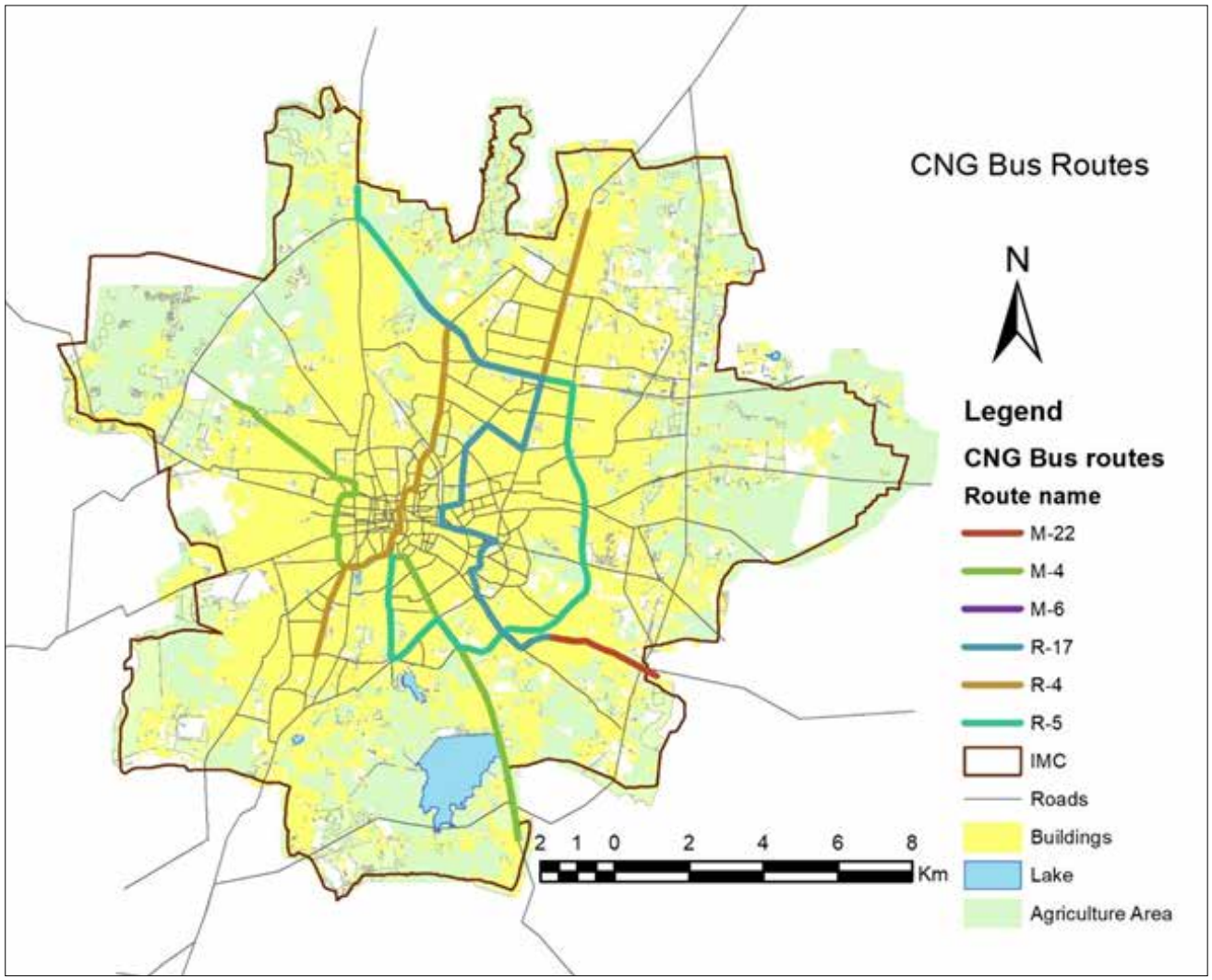
Currently, IMC is using the generated Bio-CNG for public transportation within the municipal boundary of the city. There are six routes where these CNG buses run: M-4, M-6, M-22, R-4, R-5 and R-17. The routes are shown in Figure 11. With the newly launched Bio-CNG plant at Devguradiya, 200 buses will be able to use CNG as a fuel. However, as per stakeholder consultations, more sustainable measures for transportation would be required to achieve a green future.

3. Discussion and Conclusion

From the primary and secondary studies carried out for the Bio-CNG projects in Indore, it can be noticed that the government is making tremendous efforts to make the city liveable and develop sustainably. The efforts of common citizens and city authorities are noticeable in the outcomes of the implementation of such projects. The city's work is also leading towards achieving the SDGs; there are four SDGs mentioned in the abstract that the project aligns with.

The city has thoughtful and reliable strategies to balance its funds and economic needs, not only for this project to function, but for all the projects important for its development and stability. Another appreciable aspect is the city officials' acknowledgement of the importance and the role of the citizens in the success of this project. Awareness among the citizens of their contribution towards the project has also increased. Thus, the project has set a high benchmark for other cities to follow for their sustainable development. This project has been highly appreciated at the global level and attracted many visitors who have visited the plant to understand the process and effort behind it.

The project has an immense role in the sustainable growth of Indore and has created a good economic opportunity for the city and the companies operating the plants. As the city is investing in greener projects, it is expected that more environment-friendly projects would take place in the future, which can set Indore as an example for Indian cities with similar built environment characteristics.



Bio-Methanation Plant (Choithram Mandi – 20 TPD)					
Monitoring Period		Baseline Emissions (BE_y)	Project Emissions (PE_y)	Leakage Emissions (LE_y)	Emission Reductions (ER_y)
From	**To**	(tCO_2e)	(tCO_2e)	(tCO_2e)	(tCO_2e)
01-04-18	31-12-18	1411	113	687	611
01-01-19	30-06-19	1070	83	257	730
01-07-19	31-12-19	1722	94	178	1450
01-01-20	31-12-20	3382	139	227	3016
Total		7,585	429	1,349	**5,807**

Table 5: Emission Reduction of Choithram Mandi Plant

Monitoring Period		Baseline Emissions (BE_y)	Project Emissions (PE_y)	Leakage Emissions (LE_y)	Emission Reductions (ER_y)
From	**To**	(tCO_2e)	(tCO_2e)	(tCO_2e)	(tCO_2e)
01-01-19	30-06-19	736	54	0	682
01-07-19	31-12-19	812	61	84	667
01-01-20	31-12-20	2689	126	93	2470
Total		4,237	241	177	**3,819**

Table 6: Emission Reduction of Kabitkhedi Plant

This study has been conducted from the perspective of an urban and environmental planner focusing on the city's growth and the environmental sensitivity of the project. This will serve as a reference study in the fields of renewable energy and sustainable development.

3.1 Implications

There are mostly positive implications of the project as per the sectors studied for the assessment. The social aspects linked to the project have improved, which is visible from the survey conducted for understanding citizen perception. The economic aspect has also grown in terms of generating funds and earning profits from this project, both for the private companies and the municipal authorities. There is no doubt that this project has considerable benefits for the environment of the city, and that too is visible in the data shown in the section on carbon credits.

3.2 Limitations of the Research

As mentioned above, the environmental, economic, and social aspects of the Bio-CNG project were the focus while conducting the primary and secondary study for assessing the project, so the outcomes also line up with the same. The study also considered spatial aspects of the plants for understanding the character of the areas and whether land use has an influence on the plant and vice versa.

3.3 Key Lessons Learnt

The project is based on the Public Private Partnership model and the coordination between the private and government sectors is worth a few lessons. The most noteworthy is the management of the three plants with their allocated dealers in a particular schedule. Although, there are issues that lead to compromises with the expected outcomes, the projects showcase that other cities can learn from the coordination in Indore within government departments and with the city's residents.

3.4 Recommendations

The review suggests the need to maintain coordination between citizens and government officials for various project components as discussed above. It further suggests looking into the social aspects while dealing with the labour engaged in segregating the wet waste and improve their working conditions. Overall, the project at its current state is performing effectively in terms of social, economic and environmental domains and has the potential to be considered as a best practices case study for an Indian smart city.

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B13

Smart Renewable energy

Smart Renewable Energy Use in Visakhapatnam under the Smart City Mission – An Appraisal

Name of the project: *Smart Renewable Energy Generation*
Location: *Visakhapatnam, Andhra Pradesh*
Year of project implementation: *2018*
Sector: *Energy*
Project Cost (Rs. Crore): *Rs 48 Crores (Approx.)*
SDG: *Linked to UN SDG Goal No. 7.2 (increase substantially the share of renewable energy in the energy mix)*

Institute: *School of Planning and Architecture, Vijayawada*
Advisors: *Dr. Ayon Kumar Tarafdar, Dr. Adinarayanane R*
Students: *Mr. Obulesh C., Ms. Atchaya N., Ms. Pranathi G., Mr. Sai Kiran, Ms. Aswathy B., Mr. Joseph*
Keywords: *Renewable Energy, Solar Power Plants, Energy Efficiency*

Abstract:

Smart City Mission in Visakhapatnam, coordinated by GVSCCL has been innovative and exemplary to invest on smart renewable energy generation, aimed at long term energy sustainability in the city. The purpose has been to lead in terms of solar power generation and set examples of solar power generation. GVMC under the coordination of GVSCCL has set up floating solar panels in the city's water bodies, and converted barren vacant land into land based solar power generating nodes. Subsequently, it has also started utilizing the rooftops of government properties to generate solar energy. This report attempts to study this project and bring out its key achievements, scope of improvement and possibilities of replicability and scalability.

Case Study: **B13**

1. Introduction

Visakhapatnam (also commonly known as Vizag, Visakha, or Waltair) is the largest and most populous city in the Indian state of Andhra Pradesh, as well as the state's proposed administrative capital[1]. It is also the headquarters of Visakhapatnam district and one of the four smart cities in Andhra Pradesh, as designated under the Smart Cities Mission of Government of India. As a part of the Smart City Mission, the Greater Visakhapatnam Smart City Corporation Limited (GVSCCL) undertook several significant projects, one of which was generating solar power at the municipal corporation level in three innovative manners that can sustain municipal energy requirements to a great extent.

As a part of the research initiative titled "Smart Cities and Academia Towards Action and Research (SAAR)" which is a project under the Ministry of Housing and Urban Affairs, Govt of India, coordinated by NIUA, this research report attempts to appraise the innovative solar energy generation projects in Visakhapatnam city.

1.1 Topic and Context

Visakhapatnam is a rapidly developing city with rising energy demands. The exponential rise in energy requirements of the city in the last one decade has been, the accelerated population growth and rapid technological advancements in the administration of the city. As Visakhapatnam is projected by many as the next administrative capital of the State of Andhra Pradesh, the land value, real estate development, industrial and commercial sector and the population, have all grown in multiple dimensions. Between 2001 and 2011, the city's spatial extents increased by 91.8 percent. In 2005, the municipal territory was expanded to include Gajuwaka and 32 villages and the Greater Visakhapatnam Municipal Corporation (GVMC) was formed, which resulted in an increase in spatial extents and population. The zones of Anakapalli and Bheemli were added to GVMC's limits in 2013. After the state was bifurcated into Telangana and Andhra Pradesh, Visakhapatnam became the industrial and ITES hub of the state. The city occupies the 122nd spot on the list of world's fastest-growing cities.

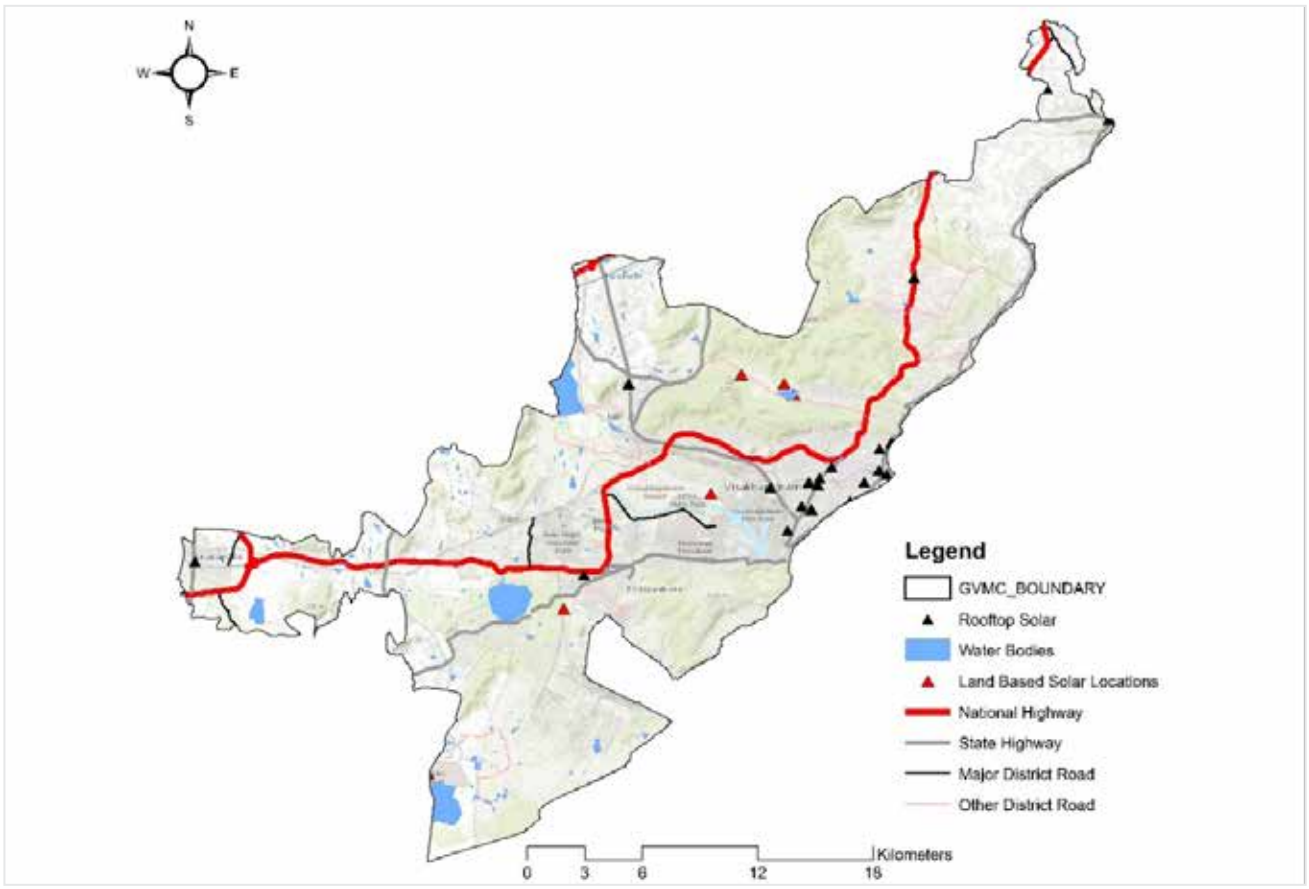

Figure 1: Location of all the solar power generating hubs in GVMC boundary

Many factors have contributed to Visakhapatnam's status as an industrial capital, including the presence of steel mills, NTPC, and naval stations. The city already boasts the presence of a large steel plant, an important naval base, a large port and several pharmaceutical industries. The amount of electrical power accessible for residential and administrative buildings has become limited as businesses have grown. The thermal power plant of Visakhapatnam was the city's main source of power. The thermal plant uses coal to generate electricity, which has a tremendous carbon emission factor. The city was envisioning for long to have an alternate power source. While majority of Indian cities of the scale and type of Visakhapatnam would be contemplating another thermal or hydro-electric power plant, Visakhapatnam thought of innovating in the field of renewable energy. In this backdrop, the Greater Visakhapatnam Smart City Corporation Limited (GVSCCL)[2] conceived that there is a need to transition to smarter energy alternatives as well as achieve energy self-sufficiency. As a result, the smart city initiative conceptualized solar energy generation as the vehicle towards transformation. Instead of trying to tap only the rooftops of government buildings, it took a step further to think of floating solar panels and land based solar panels.

1.2 Project Background

The city of Visakhapatnam is bestowed with an ample supply of sunlight. More than 12 hours of sunlight is available for eight (8) months during the year. In the state of Andhra Pradesh, the average sun irradiation is 1266.52 W/sqm. On an average, a 1kWp solar rooftop plant can create 5.0 kWh of power each day over the course of the year (considering 5.5 sunshine hours). Considering the ample summer season of the city and clear sun-light for several months, GSCCL zeroed on to renewable sourced energy generation as a major component of the smart city initiative. In Visakhapatnam, the solar components, are primarily focused on three areas: rooftop solar components, floating solar panels, and land based solar panels. The Mudarasalova reservoir is home to the floating solar power generation project. It covers a total area of 4.4 acres. There are two land-based solar power generation projects which can be found in the Krishnapuram WTP facility and near the Mudarasalova reservoir. These, cover 4.5 acres of land near the Mudarsalova reservoir. In addition, solar panels have been installed at suitable locations on the rooftops of the GVMC office buildings and its parking spaces.

For the present project, however, two spots from the above were studied in depth for a clear understanding

[1] *Visakhapatnam is reported to be elevated to the status of administrative capital of Andhra Pradesh state in the future. However, a formal legislative announcement is yet to be made.*

[2] *Greater Visakhapatnam Smart City Corporation Limited (GVSCCL) is a government formed special purpose vehicle incorporated in lines with Companies Act and functions like a Corporation. It is responsible for coordinating, executing and monitoring the Smart City Mission components in the city. It is a corporation with representatives from various departments of the State Government.*

of the overall initiative and its implications on the city of Visakhapatnam. The project management consultancy firm for the projects related to solar power plants within the city, is AECOM Asia Company Ltd.

Figure 1 as presented herewith, shows the location of all the solar power projects in the city with respect to the GVMC boundary. Figure 2 as presented, shows the location of the floating solar power projects in the city and Figure 3 as presented, show the location of all land based the solar power projects in the city.

1.3 Smart Renewable Energy Generation Projects of Visakhapatnam: Highlights

Solar energy is a renewable energy source that is dependable, economical, and extremely safe to utilize. The GVSCCL aims to eventually utilize all the possible vacant public spaces in Vishakhapatnam city to generate solar energy. Solar energy has the potential to minimize carbon emissions and offer a much cleaner alternative to conventional energy generation. It also has the potential to lower electricity prices and attain energy self-sufficiency.

While solar energy is often getting promoted and visible at the household and corporate levels, finding solar energy as the source by urban local bodies is still rare in India. Visakhapatnam city decided to forgo all the technical and administrative hurdles to emerge as the country's first floating solar power generating urban case study. This led to several projects across India to be developed emulating the Vizag Model.

It is also significant that the power thus generated, seem to compensate the energy requirements for water and sewerage treatment for the city, thereby adding the critical component of sustainability in the civic administrative processes. At present, the project is being implemented at a small scale at 5 locations. The panels have been placed on the government buildings, vacant land plots owned by the government, and on one large water body. But each of them has a potential for replicability. The solar panels have been installed in such a way that they take advantage of the open spaces and regions that are typically left unused. Moreover, the use of innovative technologies such as sensors to monitor the intensity of the sun and turn the directions of the panels as the sun moves, are reaping much higher quantum of energy.

In the subsequent sections, we shall describe and highlight the components of the smart renewable energy generation project in more details.

2. Smart Renewable Energy Project Appraisal

2.1 The Study Concept

This report shall first explain the initiatives undertaken in more detail on the basis of the site visits and discussions with the staff maintaining the solar power generation projects. Then, the report shall try to bring out the perception of the users and beneficiaries of these projects. Finally, it would indicate the areas and scope of improvement or replication.

The data related to the project was obtained from GVSCCL officials and supplemented with site visits in March 2022, where interviews were held with the technical staff and authorities who are responsible for the operations and maintenance of the facilities. The maintenance of these projects and assets have been outsourced to a company through a long term maintenance contract. Further, group discussions with the GVSCCL officers and local residents near these projects were held, to understand the general perception.

The smart renewable energy generation projects is understood to have been introduced through three typologies of power generation. They are, (a) floating panels on water bodies, (b) rooftop generation in government buildings and (c) vacant public land with panels. The table herewith summarizes the various ongoing projects of renewable power generation in the city.

In the subsequent sections, the project specifications have been discussed in detail.

2.2 Project Summary

As is evident in Table 1 (Annex One), there are three typologies of solar power generation projects initiated by GCSCCL. Each of them are unique and innovative in their own manner. The following sections take up each type and brings out their respective levels of uniqueness.

2.2.1 Floating Solar Panels

The floating solar power generating panels are found in a large urban lake called Mudarasalova which is about 4 acre in size. About 20% of the lake's area has the solar panels floating on its surface. The fresh water lake is surrounded by hills and forest and has a few streams flowing into it. The lake depends on seasonal surface run-off of its catchment area and does not have a perennial source. The solar panels are suspended on top of 4mm HDPE pipes that have been vacuumed and foamed. Polycrystalline and Monocrystalline solar panels float above the water's surface. They measure 0.9m X 1.98m in size. Each panel produces around 350 W/hr (going upto a maximum of 370 W/hr). All of them together

Figure 2: Location of Floating Solar Power project in GVMC boundary

Figure 3: Location of Land Based Solar Power project in GVMC boundary

have a DC output of 2MW. On the 18th of August 2018, the 2 MW unit was connected to the grid. At present there are about 6250 320Wp Poly crystalline modules floating in the lake. The double-glazed panels utilised in this project are from abroad. Each panel is made up of 72 cells. The SMB (String Monitor Box) collects the DC current generated by the panels and sends it to an inverter, which converts it to AC. The energy produced here is fed into the grid (KBR) and distributed to the rest of the region. Access to the panels in the middle of the reservoir is through a floating bridge and boats. Serviceability of the floating is a little difficult. However, due to lack of dust, cool micro-climate and absence of human intervention in the middle of the lake, the need for servicing is also limited.

2.2.2 Land Based Solar Panels

Land-based solar panels are those that generate electricity by utilising available vacant public land. In Visakhapatnam, there are three such sites where power is being generated by placing panels on vacant government land. The panels are positioned in such a way that they align with the sun's orientation and movement at different times of the day. This improves the panels' efficiency and generates more power. The power producing capacity is 1MW for each of the three projects, with a DC output. The total area of the land under this typology is 11.5 acres spread over three sites. Monocrystalline solar panels are used. The Krishnapuram Water Treatment Plant which is close to the city center is one of the project sites. It generates a total of 2981.1 MWh of electricity per year. It has a total area of 6 acres. As a result, the electricity bills/ year are reduced by Rs. 1, 90, 49,469/- approximately, as per records. Additionally, CO2 emissions are estimated to be reduced by 2,541 tons per year. Also, each year, 1,271 tons of coal gets saved.

2.2.3 Rooftop Solar Panels

Rooftop solar panels have primarily been installed on state-owned buildings. The total the electricity generated under this typology is is 700 kilowatts. One of the major initiative is on top of the town's ground level water supply reservoir. Also, in the GVMC Government Office, solar panels have also been put on top of the parking spaces which act as shades below. Solar panels with a surface area of ten square meters create one kilowatt of electricity from this project. The building faces south and panels are tilted to match Visakhapatnam's latitude of 17 degrees. Panels are also installed on the terrace of the 144 GVMC schools. Rooftop Solar Power Plants with a capacity of 0.215 MW (i.e. 215 kW) have been installed and commissioned over the course of 6 months.

2.2.4 Street lights with solar panels

In some areas of the city, the need for street lighting is critical. The installation of solar-powered stand-alone streetlights solved the problem, and the fact that they were stand-alone made maintenance and monitoring of the lights easier. The beach road and the ABD area has thse standalone solar power generating street lights. The sensors improve the efficiency of the lighting even more, by switching off or dimming the lights if there is no activity below the pole. The solar street lights can be found over a 5-kilometer section of Beach Road. Each street light panel produces around 44 watts of power. Monolithic crystalline panels were utilized in this project. The poles are equipped with Li – Lithium batteries that provide a three-day backup.

The light bulbs in the poles have a lumens-per-watt rating of 180. The side poles have nine panels, while the median poles have four. The side poles have a capacity of 360 watts, whereas the median poles have a capacity of 180 watts. The side poles are 6 meters tall, while the median poles are 4 meters tall.

The side poles are spaced at a 25-foot interval. Solar panels, lights, and a pole with RMS control make up the integrated street lighting. Internal roads in the ABD area have these installed. The LED chips have a lumen-per-watt rating of 180.

According to the responses of the GVSCCL staff, maintenance staff and local residents, the regularity with which the panels were serviced was good. The panels were not found to be vulnerable to natural disasters, and they were relatively easy to shift after installation. Even after installation, the aquatic life remained healthy. The output efficiency and fault resistance were both typically perceived to be good. The project was estimated to be as low maintenance and low repair in nature.

Plate 1. Floating Solar Panels in Visakhapatnam

Plate 2. 6250 floating panels in Visakhapatnam

Plate 3. Land based solar panels under GVSCCL

Plate 4. . Land based solar panels under GVSCCL

Plate 5. SPAV team inspecting upgraded playground & Multi-Use dais in Primary School, GVMC Waltier II

Plate 6. SPAV Team inspecting GVMC maintained land based solar panels

Plate 7. Inverter Rooms converting DC power from Solar Panels to AC, with real time monitoring

Plate 8. Land based smart solar panels that change directions as per sun path, maintained by GVSCCL

2.3 Perceptions on Land Based Panels

The general service frequency, susceptibility to damage, and time during which the service was offered for the land based solar panels were all satisfactory. The efficiency of the panels did not change over time, and the output uniformity was good regardless of the season. Staff maintaining the panels observed the functioning and operations to be simple and hassle free without much inputs required.

2.4 Perceptions on Rooftop and Street Lights

The spacing between the lamps, the condition of the pedestrian movements after installation, and the distribution homogeneity were all perceived to be good by the local residents and pedestrians. The frequency of service and the amount of time the serviceman was available were both found to be exceptional. It was observed that technical support was readily available, and the risk of damage was low. The output consistency throughout the night was decent to exceptional, as was the functionality of the daylight sensors.

2.5 Willingness to Pay

The study asked respondents, who were employed citizens from different backgrounds in the city of Visakhapatnam about their willingness to pay for similar new projects which can be taken up by the city authorities and maintained by them. They were asked about their willingness to pay for one time as for the capital investment for such projects, if announced in future with greater details. The results indicate mixed viewpoints for floating, land-based and rooftop solar plants.

There is a greater inclination towards floating solar power plants as respondents appear to be aware of its existence and significance (see fig 5 in comparison to fig 4). In the case of land based solar power plants, about 53% remain non-committed, whereas in the case of floating power plants, only 39% are non-committed. They are less inclined towards land based power plants, possibly due to the shortage of land in the city and the limited access and

The chances of ownership of land for the citizens. In the case of rooftop based solar plants in public or government buildings, the willingness is maximum. Citizens are more inclined towards public large scale projects than installing them individually, thereby indicating high levels of awareness regarding benefits and long term use of such projects.

3. Inferences

3.1 Implications and Benefits of the Project

There are several benefits of these solar panel power generating projects. Each of these projects have immense potential for replication and long term positive attributes. Investing on renewable power generation projects by the municipal corporation indicates a public sector choice of aligning with green and clean technologies. The projects are not technically complicated and neither are they financially challenging. Visakhapatnam has simply demonstrated a vision and commitment to smart innovative and environmentally inclined solutions to basic needs. Some of the essential and benefits of the project are as below:

i. **Urban Blue as Fundamental Infrastructure:** Urban water bodies are essentially large areas of land with no shade. They provide an excellent opportunity to harvest the solar energy generated. In compared to other types, the cost of upkeep is inexpensive and much lesser as accumulation of heat on water surfaces are lesser than land based or rooftop based solar projects where there is high albedo and radiance factors. Solar panels have no negative impact on the reservoir's water quality or aquatic life. Such projects also have anything to do with the existing thermal power plant system. Power generation from solar panewls are connected to the thermal power plant, and as the power output from the solar cells increases, the demand from the thermal power plant decreases through automation.

ii. **Upkeep of Water Quality:** The installation of the panels have led to strict monitoring of the water bodies in terms of water quantity, perimeter control and frequent visits by technicians. All these prevent unauthorized encroachment or waste disposal into the lake.

iii. **Utilization of Vacant Usable Land:** To generate electricity, the land based solar facilities makes use of undeveloped barren and rocky terrain. Scrubland and rocky waste land can be easily utilized to set up solar panels which can harness the immense amount of sunlight in the region. The orientation of the cells with relation to the sun's orientation ensures that the maximum amount of energy is utilized. Automation where the panels rotate as per sun movement ensures greater generation. It has no negative impact on the land or local environment. There is no pollution of emission from such projects and the land remains intact.

iv. **Government Buildings which are Energy Efficient:** The installation of solar panels on each government building has changed the manner in these government offices maintain their premises and use energy. The amount of solar power generation is monitored in each building and seen as supplement to the requirement in the offices. Over time, the offices aim to regulate their usage in relation the generation from their own panels. The reduction in CO2 emissions (in tons per year) is substantial. The annual electricity bill savings amount to 0.20 crore rupees for GVMC alone. Every year, 151 tons of coal can be estimated to be saved by the use of these renewable energy. These panels do not need additional built up space because they are installed on the rooftops which are the most underutilized part of the government structures.

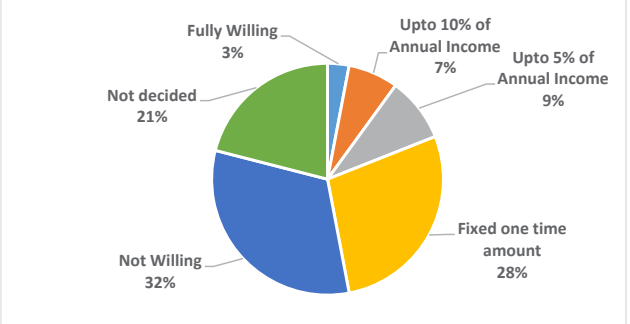

Fig 04: Willingness to Pay for New Land Based Solar Power Plants in Visakhapatnama

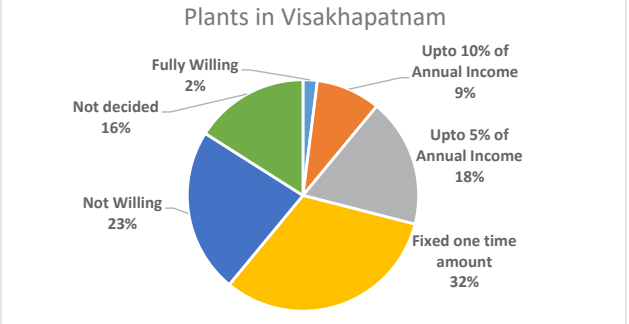

Fig 05: Willingness to Pay for New Land Based Solar Power Plants in Visakhapatnam

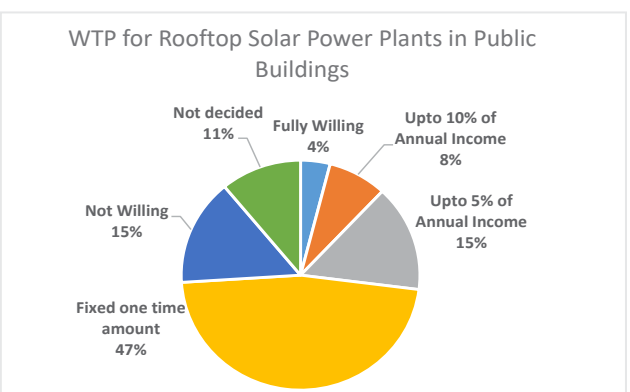

Fig 06: Willingness to Pay for New Land Based Solar Power Plants in Visakhapatnam

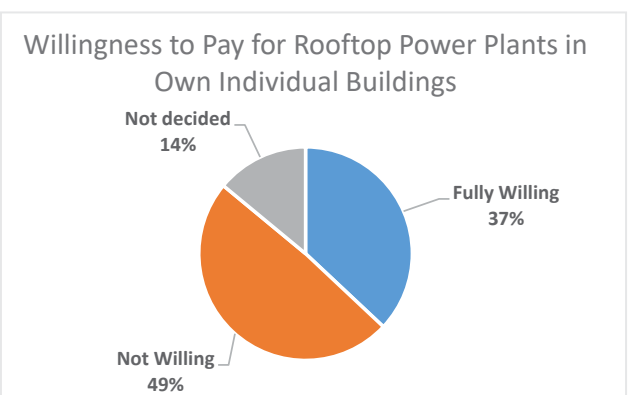

Fig 07: Willingness to Pay for Rooftop Solar Power Plants in Own Individual Buildings Visakhapatnam

v. **Smart Streets with Enhanced Safety:** Converting traditional street lights into self-sustaining freestanding solar street lights, balances costs associated with trenching, procurement, and power cable laying, among other things. Automated smart street lights that save energy by dimming when activity is reduced under it enhances the efficiency of the lighting system. Smart street lights also light up the street based of amount of light available around it, automatically when sunlight is reduced or it's dark. Solar Street Light with a capacity of 0.173 MW has been installed and commissioned. The total amount of energy produced per year (MWh) is 189.4. The reduction in CO2 emissions (in tons per year) is 242. The annual electricity bill savings amount to an estimated 0.12 crore rupees in Visakhapatnam.

3.2 Scope of Improvement

The initiatives related to renewable energy generation are exceptional and exemplary. There have been many other municipalities in India who have studied the model of Visakhapatnam and developed their own floating and land based solar power generating projects. However, it is also equally important to understand that the generation capacity of all these projects put together is not equal to the demand of the city or even the public buildings. Hence, there is a need to think of augmentation and scalability. These projects are almost 5 years old and are reaching its peak performance. There is a need to replicate and increase generation capacity. Otherwise, its impact and benefits may not be appropriately recognized across the city. The power generated from these utilities are presently equated against the WTP and STP energy demands of the city. However, if the power generated is equated with the entire energy demand of the government sector of the city, then the need to scale up the projects shall be appropriate.

3.3 Scope of Replicability and Scalability

In this section, the report puts forth a basic and conceptual estimation of the quantum of solar powered energy that can be garnered in Visakhapatnam city in future from residential sector alone. The residential zones of the city has been assumed to be complying with the proposal of having part of their rooftop area to be turned into solar panel coverage. The estimation is based on basic calculations of available residential building footprint areas in each ward. This footprint area was extracted from satellite imageries and their basic interpretation. Thereafter, it was assumed that a maximum of 55% of the available rooftop area can be utilized towards solar power generation, with appropriate incentives from the government. Thereafter, the available areas of each ward was taken for calculating the solar rooftop solar power plant capacity in each ward. Based on the estimated capacity in each ward, the annual estimated electricity which can be generated has been tabulated. The final column of Table 3 is estimating CO2 emission mitigated from the rooftop solar power generated. For CO2 mitigated, it is assumed that the solar energy generated is reducing the need to generate traditional methods of electricity generation.

The CO2 mitigation for each ward is thematically depicted as a part of the subsequent city map presented herewith.

This estimation is a fictitious scenario, which can be achieved with policy and strategic support. Implementing rooftop based solar panels in residential zones is always a challenge as the private households and dwellers may not be motivated or equipped enough to invest. However, it is significant to understand the massive volumes of electricity generation capacity that remain untapped in a zone like Visakhapatnam.

It is also to be mentioned here that while residential zones maybe not fully accessible, it is easier to envision the government and public buildings to have compulsory rooftop solar panels. The use of all unused vacant land,

Plate 9. Rooftop Panels over Water Reservoir in Visakhapatnam

Plate 10. Solar panels over GVMC Parking in Visakhapatnam

Plate 11. Solar Panels in Parking at GVMC headquarters

Plate 12. SPAV Team inspecting smart street lighting at Visakhapatnam

Plate 13. Smart Solar Street Lights at Beach Road, Visakhapatnam

Plate 14. Self lighting and self dimming solar powered street lights at Visakhapatnam

water bodies and canals for floating or fixed solar panels can be replicated for smarter and environment friendly solutions.

4. A Summary of Thoughts

Energy sector in urban areas of India is bound to feel a massive pressure of demand and a possible crisis of supply in coming times. The growth of energy demand has been exponential in most of urban India. With increasing affordability, greater purchasing power parity and high per capita income, the use of high wattage appliances, and the demand for high consumption of energy is inevitable. In this light, there is a natural and instrumental requirement for most fast growing cities to look towards greener and cleaner alternatives. The abundance of solar energy in the tropical zones bring forth an enormous potential. Visakhapatnam, lying in the hot zone of tropics, has more than 8 months of strong and warm sunlight. It is pertinent to think of renewable energy sources. GVSCCL has already set the ball rolling with state of the art installations of solar panels. The management and operations have been outsourced and the city is already reaping its benefits. However, the quantum of positive impact is limited compared to the demand and consumption of the city. Therefore, with replication and scaling up of such projects, it is quite possible that Visakhapatnam becomes the solar power generating capital of the nation.

While smart city is often interpreted with automation, use of apps, cloud computing and AI to deal with city administration, it is also pertinent to take up basic fundamental projects that indicate paradigm shift in the way we use and generate energy. The replication of solar power plants in the city of Visakhapatnam in any format with the coordination of GCSCCL, is therefore highly recommended, considering the high levels of awareness and acceptability of the citizens due to the existing successful projects, the reduced energy demand for the city and the potential reduction in carbon emissions due to a shift to cleaner and greener technologies.

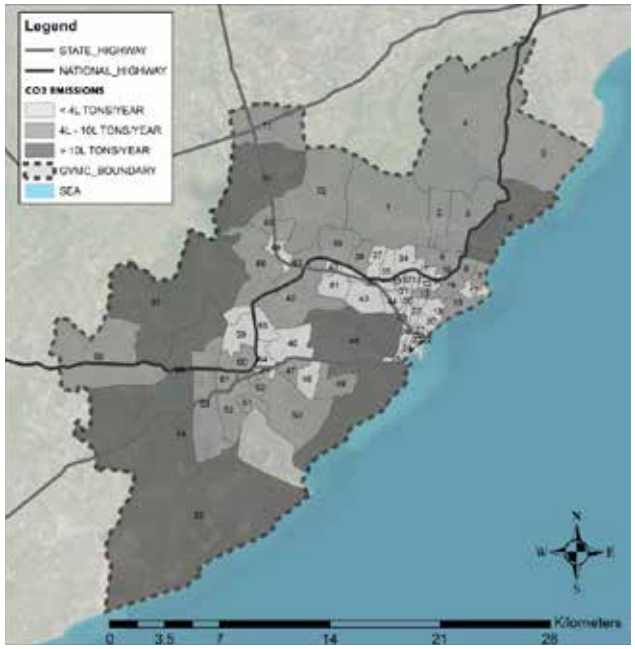

Fig 08: Effective CO2 Emission Mitigated in Each Ward based on Rooftop Solar Panel Installation in Residential Zones (Estimated Scenario)

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1. Annex One

SL.NO	Plant Name	Type of Component	Plant Capacity(kWh)	Expected Generation @ 4 units per kW/day (kWh)	Actual Generation from SPV Plant (kWh) {A}	Net Savings for the month (Rs) {AX Unit Price)
1.	GVMC Main Office	Rooftop	258.2	32,017	15,153	1,16,071.98
2.	TSR Complex	Rooftop	787.52	97,652	93,407	5,91,266.31
3.	NARAVA WTP	Land Based	365.92	45,374	20,533	1,29,971.99
4.	Vepagunta (Zone -08)	Rooftop	11.52	1,428	522	3,999.29
5.	GVMC Surya Bagh (Zone – 04)	Rooftop	44.8	5,555	4,979	38,137.61
6.	GVMC GAJUWAKA (Zone – 060	Rooftop	25.6	3,174	2,259	17,306.24
7.	GVMC Madhurwada (Zone – 02)	Rooftop	8.96	1,111	898	6,879.60
8.	GVMC Bheemili (Zone – 01)	Rooftop	9.6	1,190	1,123	8,599.58
9.	GVMC Gnanapuram (Zone – 05)	Rooftop	6	744	619	4,743.15
10.	KBRB Pump House (H.V Issue)	Land Based	18	11,110	3,620	27,729.97
Total			1536.12	1,99,355	1,43,113	9,44,705.72

Table 01: Summary of Solar Power Generating Projects in Visakhapatnam under Smart City Mission
Source:

2. Annex Two

2MW PROJECT - Mudarasalova Reservoir, Vishakaptnam	
Plant Capacity	2MW 2000KW
Total No of moduels installed	6250
Type of PV Modules	Poly chyrstaline,72 cell
Nominal power watt	320watts
Voltage and Current Ratings of Pv Modul	37.13 volts & 8.62Amps
PV Modules eficiency	16.31%
Total no of SMBS (String Monitoring Box	16 Nos
I/P'S & O/P'S Of SMB	12 IN & 1 OUT
Nos of strings per smb	10 strings
No of modules per string	14 nos
No of SMBS per inverter	8 nos
Total no of inverters	2 nos
Inverter ratings	1000kw,400v,1445 amps
HT Breaker ratings	33 kw,630 A, indoor type
No of transfomers installed	2 nos main & auxillary
Main Transfomer rating	1000 KVA,33KV/400V
Weather Station	1 Unit
Sensus used weather station	pyranometer, temperature, humidity, rain gauage, anemometre
Scada	1 unit

Table 02: Summary of the Mudarasalova Solar Project
Source:

3. Annex Three

WARD NO.	Cumulative Rooftop area in the wards (in sqm)	The Area Available for Solar Panels (in Sq M)	Cumulative size of plant in each ward (in KW)	Annual Estimated Electricity Generation in Kwh	CO2 emissions Mitigated (in Tons)
1	243429.59	131451.98	13150	19725000	404400
2	248711.46	134304.19	13430	20145000	413000
3	295865.39	159767.31	15980	23970000	491400
4	356858.40	192703.54	19270	28905000	592600
5	285366.19	154097.74	15410	23115000	473900
6	596634.80	322182.79	34020	51030000	1046100
7	257919.69	139276.63	13930	20895000	428300
8	355205.95	191811.21	19180	28770000	589800
9	346460.39	187088.61	18710	28065000	575300
10	292609.96	158009.38	15800	23700000	485900
11	209512.85	113136.94	11310	16965000	347800
12	165616.25	89432.77	8940	13410000	274900
13	151490.57	81804.91	8180	12270000	251500
14	138719.68	74908.63	7490	11235000	230300
15	258773.90	139737.91	13970	20955000	429600
16	270592.99	146120.21	14610	21995000	449300
17	200703.30	108379.78	10840	16260000	333300
18	262586.80	141796.87	14180	21270000	436000
19	222473.55	120135.72	12020	18030000	369600
20	221722.84	119730.33	11970	17955500	368100
21	66559.20	35941.97	3590	5385000	110400
22	90227.43	48722.81	4870	7305000	149800
23	117428.77	63411.53	6340	9510000	195000
24	136670.54	73802.09	7380	11070000	226900
25	75367.15	40698.26	4070	6105000	125200
26	163269.44	88165.50	8820	13230000	271200
27	179928.61	97161.45	9720	14580000	298900
28	106375.87	57442.97	5740	8610000	176500
29	71613.08	38671.06	3870	5805000	119000
30	154724.31	83551.13	8360	12540000	257100
31	152903.33	82567.80	8260	12390000	254000
32	170218.39	91917.93	9190	13785000	282600
33	111732.86	60335.75	6030	9045000	185400
34	187970.76	101504.21	10150	15225000	312100
35	229532.23	123947.40	12390	18585000	381000
36	85491.24	46165.27	4620	6930000	142100
37	127523.55	68862.72	6890	10335000	211900

WARD NO.	Cumulative Rooftop area in the wards (in sqm)	The Area Available for Solar Panels (in Sq M)	Cumulative size of plant in each ward (in KW)	Annual Estimated Electricity Generation in Kwh	CO2 emissions Mitigated (in Tons)
38	373119.58	201484.57	20150	30225000	619600
39	379588.93	204978.02	20500	30750000	630400
40	213483.98	115281.35	11530	17295000	354500
41	220343.20	118985.33	11930	17895000	366800
42	256404.04	138458.18	13850	20775000	425900
43	120792.14	65227.76	6520	9780000	200500
44	108535.68	58609.26	5860	8790000	180200
45	760509.44	410675.10	41000	61605000	1262900
46	232168.17	125370.81	12540	18810000	385600
47	250461.48	135249.20	13520	20280000	415700
48	222561.50	120183.21	12020	18030000	369600
49	284914.79	153853.99	15390	230850	473200
50	549481.33	296719.92	29670	44505000	912400
51	308154.45	166403.40	16640	24960000	511700
52	302667.81	163440.62	16340	24510000	502500
53	419071.55	226298.63	22630	33945000	695900
54	876160.31	473126.57	47310	70965000	1454800
55	1278717.92	690507.68	69100	103650000	2125000
56	550510.86	297275.87	29730	44595000	914200
57	1095699.64	591677.81	59200	88800000	1820000
58	1306770.08	705655.84	70600	105900000	2171000
59	210051.69	113427.91	11340	17010000	348700
60	255680.85	138067.66	13870	20715000	424700
61	564256.83	304698.69	30470	45705000	937000
62	266242.60	143771.01	14380	21570000	442200
63	223682.37	120788.48	12080	18120000	371500
64	199914.87	107954.03	10800	16200000	332100
65	235995.59	127437.62	12740	19110000	391800
66	585424.09	316129.01	31610	47415000	972000
67	336125.73	181507.89	18150	27225000	558100
68	206304.47	111404.41	11140	16710000	342600
69	496696.83	268216.29	26820	40230000	824700
70	994039.85	536781.52	53700	80550000	1651000
71	562156.66	303564.59	30360	45540000	933600
72	543680.83	293587.65	29360	44040000	902800
TOTAL				1,875,536,350	38,915,400

Table 03: Estimated CO_2 Emission Reduction due to Rooftop Solar Power Generation in Visakhapatnam

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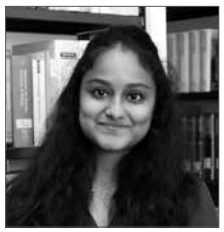

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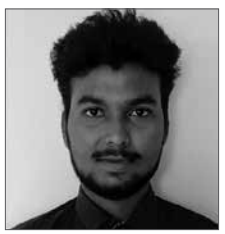

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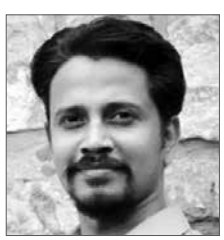

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